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PREFACE

IN his Preface to the first edition of *The Agricultural Notebook*, dated July, 1883, Primrose McConnell indicated how a personal need to refer frequently to numberless books and papers for essential farming facts—always an irksome and not infrequently a disappointing task—gave him the idea to compile a " Notebook." The success of his efforts can be gauged by the fact that some forty-five thousand copies were sold. Since it has been out of print there has been a constant demand from farmers, landowners, administrators, students, teachers, research workers and countless others who are vitally concerned directly and indirectly with food production, for a new edition.

The far-reaching developments in agriculture, both in practice and science, since the last edition in 1930 has made necessary some modification in the general scope and presentation of the *Notebook*. Whereas the first edition made no pretence of originality, but was purely a compilation of facts, the present edition has been enriched by the personal experiences of a large number of recognised authorities in the diverse facets of farming, while the essential tables of facts have still been retained. The pace of agricultural development these days, however, is so rapid, and the problems of publication of a book of this type are so considerable, that before the *Notebook* can be presented to readers new facts will doubtless be available.

I should like to take this opportunity, as Editor, of expressing my personal thanks to all those contributors, who, by their skill, knowledge and willing co-operation, have made my task so enjoyable. We only hope the result of this " combined operation " will be of help to all whose vital task it is in these anxious days to produce the maximum amount of food of which this land of ours is capable.

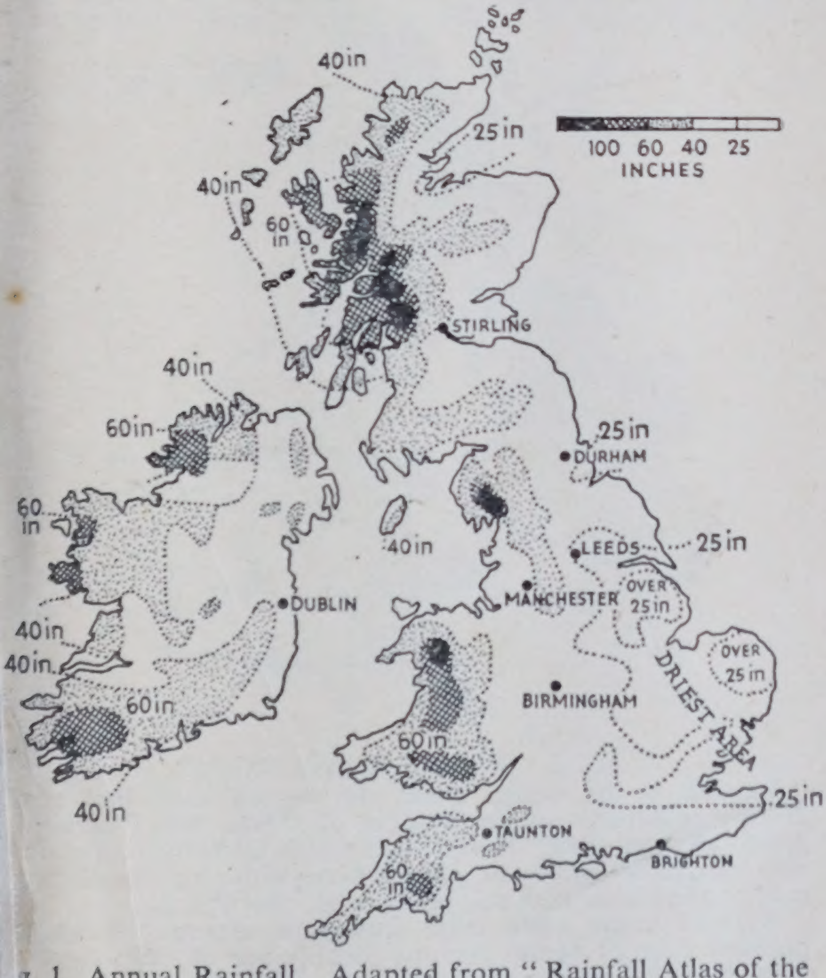
H. IAN MOORE

Seale-Hayne Agricultural College,
Newton Abbot, Devon

FEBRUARY 1953

WEATHER

Rainfall—The distribution of annual rainfall is shown in ig. 1 and the influence of high land upon rainfall is obvious by omparison of the rainfall map with a physical map of the ountry. Apart from physical features, rain increases from east



40in
25in
100 60 40 25
INCHES
40in
60 in
STIRLING
40in
60in
25in
DURHAM
60 in
40in
LEEDS
25in
OVER 25in
DUBLIN
MANCHESTER
40in
40in
OVER 25 in
DRIEST AREA
BIRMINGHAM
60in
60in
25in
40in
TAUNTON
BRIGHTON
60 in

g. 1. Annual Rainfall. Adapted from "Rainfall Atlas of the British Isles."

to west illustrated by the rainfall of places along the south coast London 24 inches, Brighton 28 inches, Bournemouth 32 inches Plymouth 37 inches, and Falmouth 44 inches.

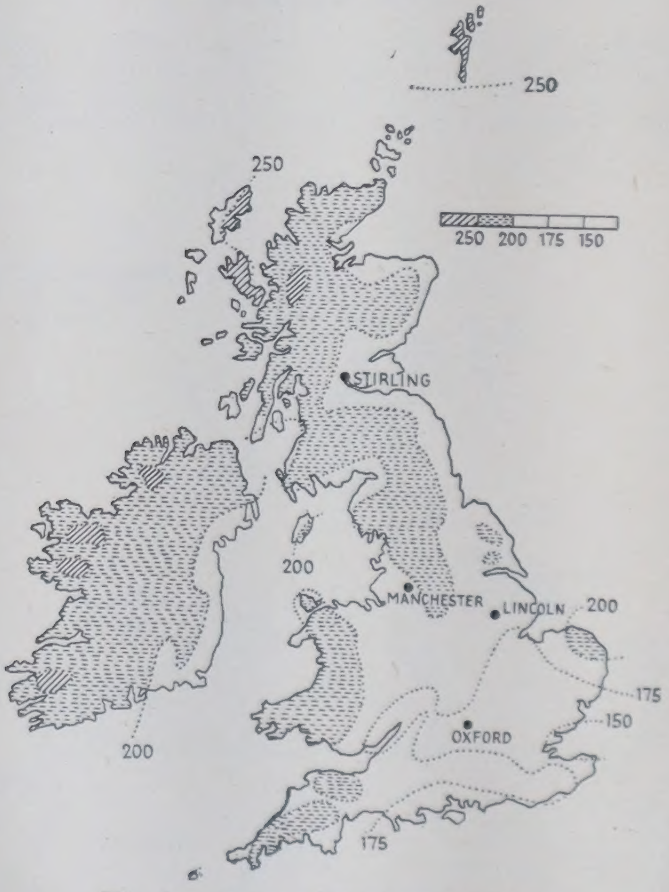

250
250
250
200
175
150
STIRLING
200
MANCHESTER
LINCOLN
200
175
150
OXFORD
200
175

Fig. 2. Areas of Highest Rainfall.

Rainfall in the wettest areas may be ten times that of th driest ; difference in the number of " rain days " is not s great. A " rain day " is one upon which 1/100 inch or more o rain falls, either by *day or night*. Places with most rain days ar confined to higher land and to the west. See Fig. 2.

Rainfall varies little from season to season and averag monthly rainfall figures for any locality are of little value as apart from the much drier, eastern counties, the rainfall for an given month varies astonishingly either side of the average. The odds against any one month being the wettest or driest can however be calculated from past records of month-by-month rainfall. The result is of limited value because a severe thunderstorm may completely alter the balance

Rain day data is often of greater value, giving a more comprehensive picture of the area under consideration.

Sunshine—In the south, summer sun amounts to about 50 per cent of the possible ; in the midlands and north, amounts fall to below 40 per cent of possible. In winter the percentage

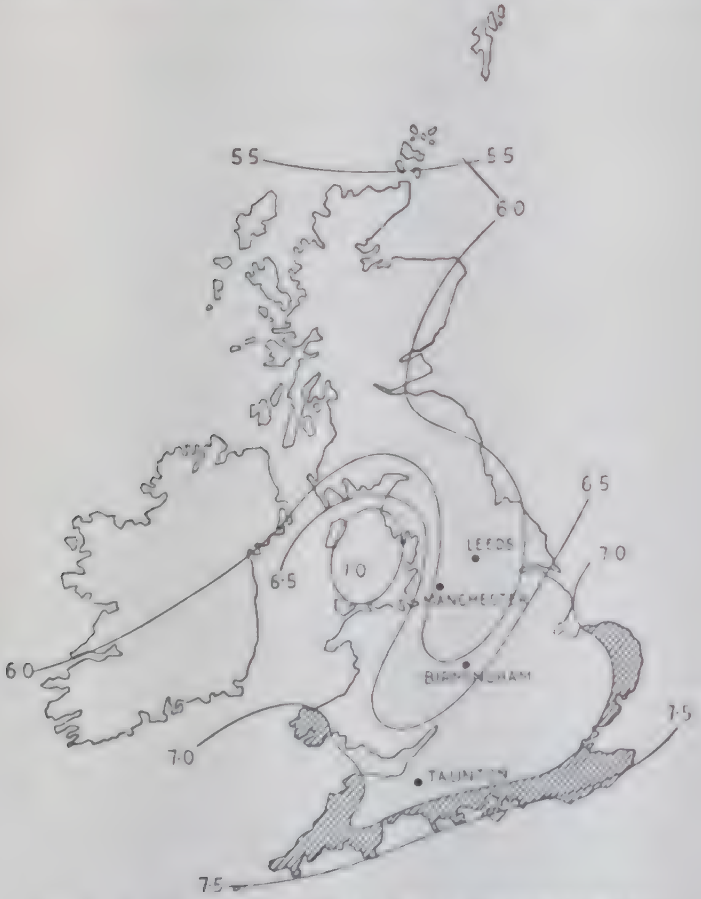


Fig. 3. Average Sunshine in June (Hours per day).

is much lower—in the region of 20 per cent of possible or less. Figures 3, 4 and 5, show the average sunshine for the British Isles in summer, winter and for the year.

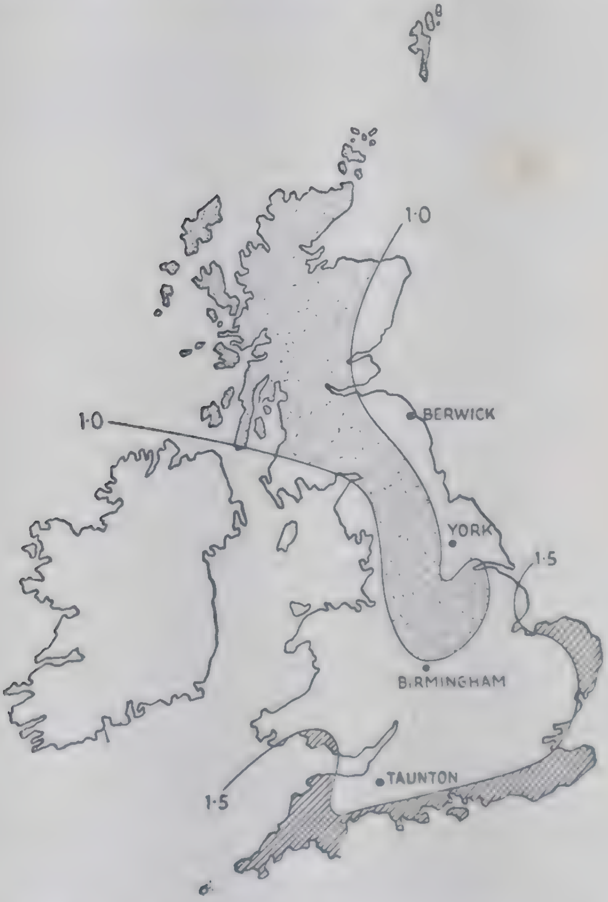


Fig. 4. Average Sunshine in December (Hours per Day).

These maps should be compared with those in Figures 6 and 7 which show mean temperature distribution for July and January.

Temperature—The distribution of July and January mean temperatures is shown in Figs. 6 and 7. The further north the colder the temperature as shown by the July map ; thus the Thames

Basin is the warmest place and Northern Scotland the coldest. This is not so in winter. Due to the high pressure regions over the Continent in winter, many winds in winter are from the east and the eastern half of the British Isles is colder than the west. Often in January or February, London can freeze, whilst the north-west of Scotland enjoys much warmer weather from the Atlantic. The warming effect of the sea in winter contributes to this effect.

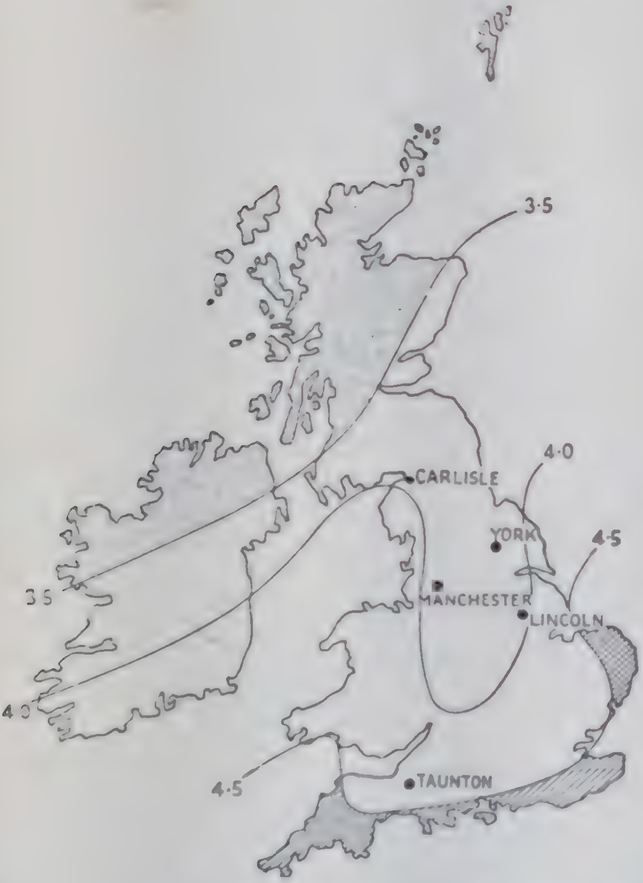

3·5
4·0
4·5
CARLISLE
YORK
MANCHESTER
LINCOLN
3·5
4·0
4·5
TAUNTON

Fig. 5. Average Sunshine for the Year (Hours per Day).

The sunshine distribution map shows the extreme south and south-west coasts to have most sun but the highest mean temperatures in summer are in the Thames Basin. (Fig. 9.

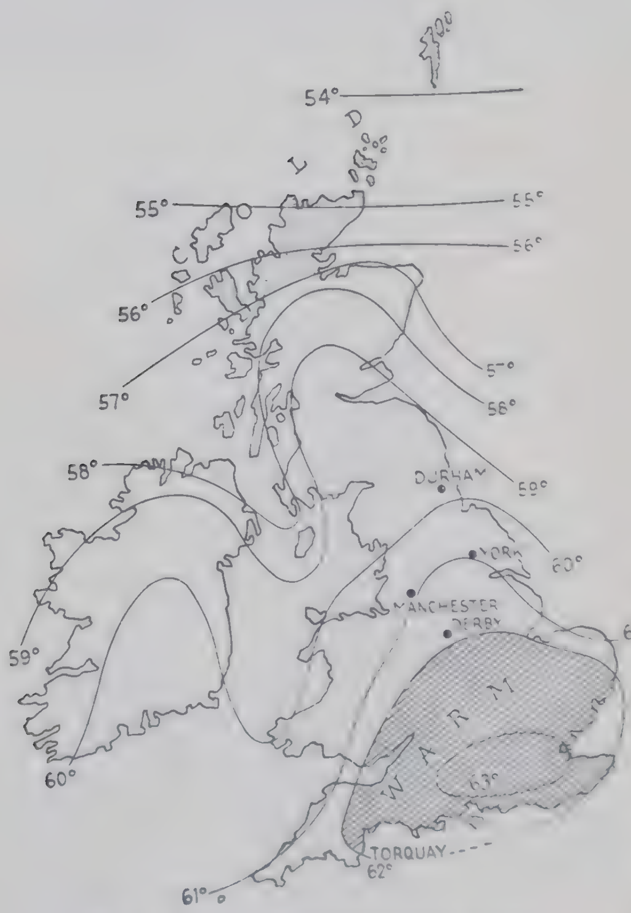

54°
55°
55°
56°
56°
57°
57°
58°
58°
DURHAM
59°
60°
YORK
MANCHESTER
DERBY
61°
59°
WARM
63°
60°
TORQUAY
62°
61°

Fig. 6. Mean Temperature in July.

The temperature distribution on the average coldest night in January is shown in Fig. 8 and the distribution of lowest temperatures on record in Fig. 10.

Generally speaking, frosts are more frequent in the months December to February, but a number of places have a high frequency of frosts in March.

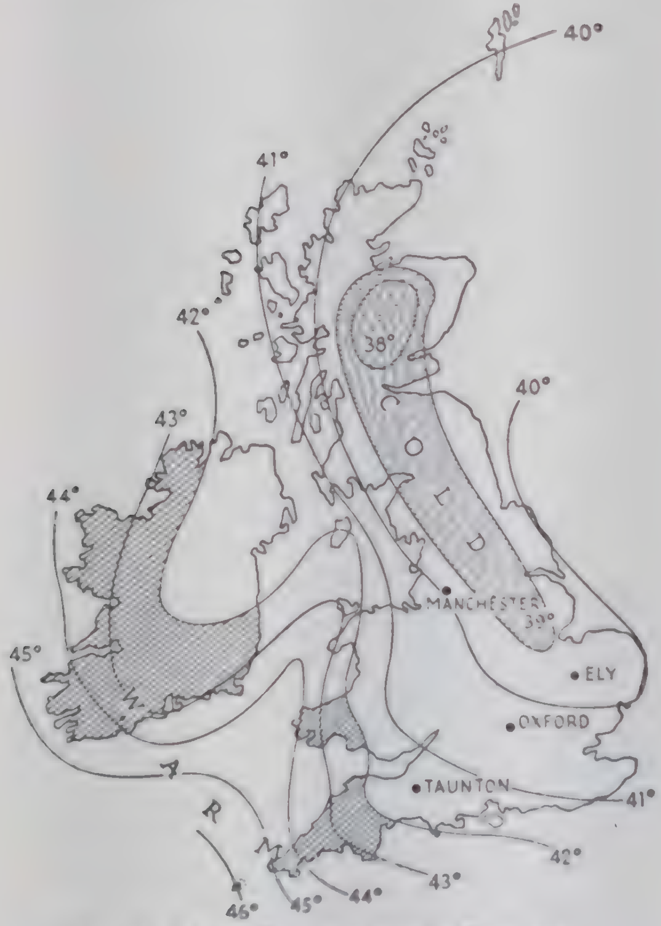

40°
41°
42°
43°
44°
45°
38°
COLD
40°
MANCHESTER
39°
ELY
OXFORD
TAUNTON
41°
42°
43°
44°
45°
46°
A
R

Fig. 7. Mean Temperature in January.

On average, ground frost is recorded on about 100 days in the year ; the Channel Islands have less than 30 frosts a year on average ; the Highlands of Scotland more than 150. As average temperature decreases with height, higher regions expect more frequent and more severe frosts. Late frosts in

May are frequent and no place in the British Isles, except perhaps the Scillies and Channel Islands, can be described as spring-frost-free. The intensity of late spring frosts is governed mainly by the lie of the land. Their frequency is *not* related to the number of fogs in March.

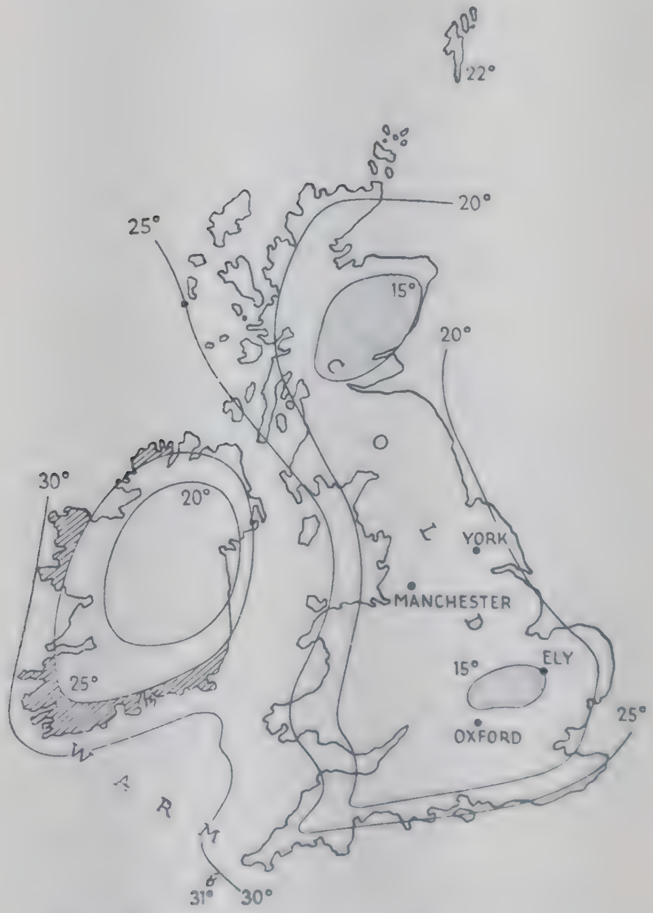

22°
20°
25°
15°
20°
30°
20°
YORK
MANCHESTER
15°
ELY
25°
25°
OXFORD
W
A
R
M
31°
30°

Fig. 3. Average Coldest Night of the Year.

Buchan's Cold and Warm Spells—More significance is attached to the dates of these than Buchan ever intended, who merely claimed a tendency towards the occurrence of cold or warm weather at the times given, and then only for south-east Scotland. (The figures were for Edinburgh alone.)

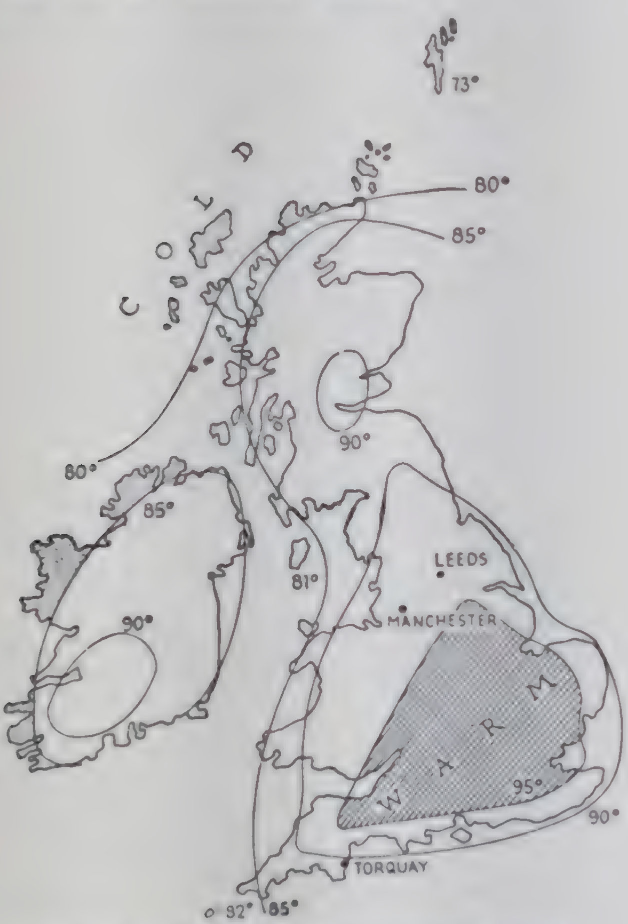

73°
COLD
80°
85°
90°
80°
85°
81°
90°
LEEDS
MANCHESTER
WARM
95°
90°
TORQUAY
92°
85°

Fig. 9. Highest Temperatures on Record.

Cold.		*Warm.*	
February	7–14	July	12–15
April	11–14	August	12–15
May	9–14	December	3– 9
June–July	29– 4		
August	6–11		
November	6–13		

Although some of the spells show with reasonable frequency in the records of the last hundred years, the level is not impressive, either in London or Edinburgh.

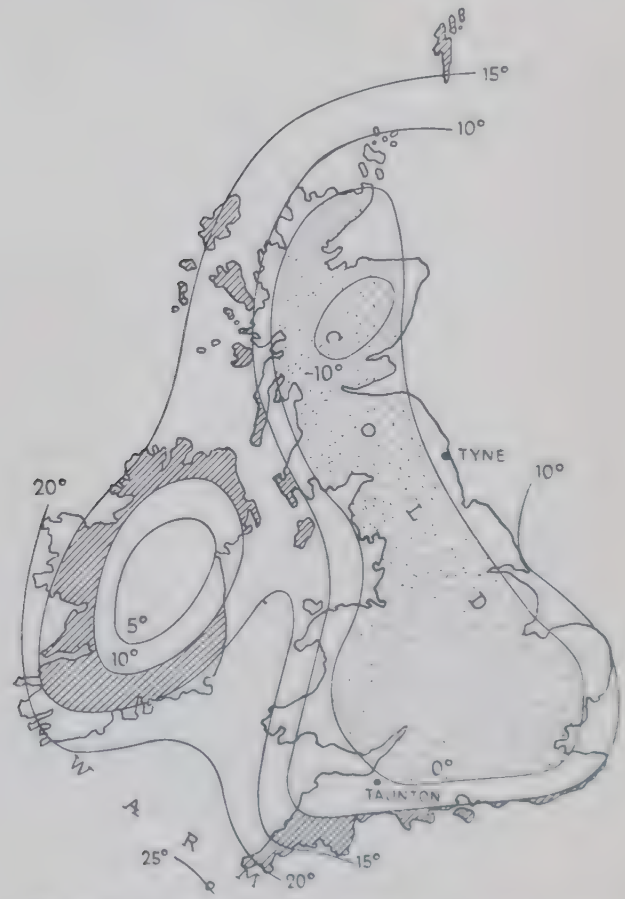


Fig. 10. Lowest Temperatures on Record.

Facts about rain—One inch of rain is about 3,630 cubic feet per acre. This is 22,622½ Imperial gallons. Approximately 101¼ tons.

Crops yielding three tons of dry matter per acre use the equivalent of nine to 12 inches of rain.

After a critical point, rain induces straw rather than grain. As a general rule, the wetter the district the lighter the soil.

The type of rain falling in a season is often more important than the amount. Prolonged steady drizzle in the late winter and spring will do more than a large amount of furious thunder rain to bring up the level of the water table below ground. It is this water table which feeds wells and springs.

Present scientific opinion suggests that rain starts from the top part of the cloud which is above freezing level. The rain is in the form of ice crystals. In falling through the cloud these crystals gather more moisture, as ice. They will, if the air temperature below the clouds is above freezing, melt and fall as rain. Otherwise they fall as snow. In a hail storm the growth of the ice crystals is rapid, due to the violence inside the cloud. The crystals become so large and fall so fast that even on a warm summer's day, they do not melt before reaching the ground.

In the disastrous floods at Louth, Lincolnshire in May, 1920, it is estimated that something like five million tons of water fell on an area of 22 square miles. Falls of nearly five inches in three hours were recorded.

There are two types of drought recognised in this country :—Absolute drought is 15 or more successive days without rain, partial drought is 29 or more successive days with a total rainfall averaging not more than 1/100 inch per day.

Attempts to make rain artificially have been successful in America. Similar work has been inconclusive in Britain and the practice is of limited economical value.

Facts about sunshine—The eleven year sunspot cycle is commonly believed to give rise to a corresponding weather cycle. The evidence is very scanty. Research over many years shows little relationship between the sunspot cycle and weather anomalies. If there is a relationship it has not yet been convincingly defined.

The heat from the sun does not warm the air. The earth is heated and it in turn throws back the heat which is then absorbed by the air.

The surface temperature of the sun is estimated at 6,000° C. The highest temperature ever measured by the black bulb thermometer—an instrument for measuring sun's direct ray heat—is just below 100° C.

In December the sun is up for eight hours a day (though seldom seen for that time) in the south of England, and six hours in the Shetlands. In June the sun is up for just over 16 hours in the south and for about 18½ hours in the Shetlands.

The solstice is the point at which the sun is farthest from the equator, north or south. The summer solstice gives us our longest day and occurs about June 21st. The sun is then farthest north and directly over the tropic of Cancer. The winter solstice gives us our shortest day and occurs about December 21st. The sun is then farthest south and directly over the tropic of Capricorn.

The equinox is the time when the sun crosses the equator and the day and night are equal in length. The spring equinox is about March 21st and the autumn equinox about September 23rd.

Facts about Temperature—Every rise of 300 feet above sea level gives a decrease of 1° F. in the average temperature.

Most farm crops in the British Isles cease growth below 40° F. As temperature is related to height above sea level, there is for any region a height above which corn crops particularly fail to ripen, e.g., wheat above 1,000 feet, oats and barley 1,500 feet.

There are maximum and minimum temperatures above and below which plant growth ceases. The temperature, high or low, at which the plant is killed is the Thermal Death Point.

Vernalisation—the pre-treatment of seed to influence plant growth and development—involves the subjection of the seed to temperatures little above freezing. Considerable work on wheat, tomatoes, beet and other plants has been carried out by British and Russian scientists.

Thundery weather does not of itself cause milk to sour; excessive temperature changes associated with such weather do the damage.

The critical temperature at which milk turns sour is between 60° and 65° F. This means that air temperature has definitely to be above 65° F. before there is any anxiety. But as soon as this level is reached some anxiety must be felt.

Once a warm spell has set in there is comparatively little danger. The sudden setting-in of a warm spell of over 65° F. causes rapid deterioration. Forecasts of unusual temperature changes, as in thundery weather, and the duration of warm spells above the critical level are of inestimable value to the large milk producer or handler.

Facts about Frost—Frost is simply a fall in temperature below the freezing point of water, 32° F. or 0° C.

A ground frost is one when the temperature recorded by the grass minimum thermometer (placed at ground level) is 30° F. or lower.

The two types of air frost are radiation frost, which occurs on calm, clear nights, and wind-borne frost which occurs only in winter when an easterly air stream is blowing from a frost-bound continent. In a radiation frost it is usually only the air near the ground which is below freezing. In a wind frost the whole air mass above the earth is usually below 32° F.

As a rule winds associated with radiation frost are only very light. Stronger winds will mix the cold air with the warmer air above and the frost disperses.

But the damaging effect of frost is much greater if there is a wind and the description of any frost involves some consideration of the wind speed.

The temperatures in calm air (as in radiation frost), and with a wind speed of about 24 m.p.h. (as in a wind frost) which will give frost of similar severity, are given below :—

	Corresponding Temperatures° F.	
Term	Calm Air	24 m.p.h. wind
Slight frost	32–27	32–31
Keen frost	26–21	30–29
Hard frost	20–11	28–26
Severe frost	10– 0	25–23
Very severe frost	Below 0	Below 23

Kent invariably suffers badly from wind frosts from the continent, the cold air being scarcely warmed by the narrow strip of sea. Further up the East Coast the sea widens and modifies the freezing east winds.

Cold air is heavier than warm air. During a radiation frost the cold air near the ground flows downhill like water, collecting in hollows and against walls and thick hedges which block its path.

It is not uncommon for plants which are fairly frost resistant to die of drought rather than of cold during a period of severe wind-borne frosts. The plant cannot absorb moisture from the frozen ground, neither can it get moisture from the cold, extremely dry, winds.

Facts about Frost Prevention—All root crops, especially potatoes, tomatoes and fruit, can suffer from frost damage. Crops for areas susceptible to extreme frost should be chosen carefully.

Early potatoes are badly damaged, not by the frost so much as by a quick thawing-out. If a late frost is usual in the locality sites facing away from the sun should be chosen.

By clearing away obstructions such as hedges and thick coppices and allowing the cold air to flow freely away down natural channels, much damage on sloping ground can be avoided.

Artificial frost prevention methods are only successful against radiation frosts. Nothing can protect exposed plants from wind-borne frost.

Facts about Frost Prevention—The three main principles of physical frost prevention are :—

(1) Adding heat ; (2) preventing loss of heat ; (3) circulating the cold air so that it mixes with the warmer air above.

Adding heat—Heat may be added by oil heaters. The best known of these is the Harrington Heater. These heaters have limitations but are often effective. Their use with other anti-frost devices—such as fans—may be an answer to the many problems of frost prevention.

Radiation heaters which directly heat the plants have been tried. Electrical devices are too costly. A new machine, the Evans Frostgard, burns kerosene under pressure to produce radiant heat which is reflected on to the ground. A heater is considered effective for one-third of an acre.

The soil itself is a large heat reservoir and special cultivation can liberate this heat. In England this is not a commercial proposition due mainly to labour costs and weather conditions.

Special irrigation of potatoes and tomatoes has been successful. The water releases latent heat when it freezes. This heat keeps the temperature above the Low Thermal Death Point and plants emerge from their ice casing in the morning apparently unharmed.

Preventing Loss of Heat—Loss of heat can be prevented by a layer of cloud. Attempts have been made to reproduce this result artificially (" smudging ") but so far without any conspicuous success.

Frost prevention by mixing the cold lower layer of air with the upper warm layer is still experimental. Large fans, up to 30 feet diameter, are mounted horizontally facing the sky. Driven by tractors, the fans draw down the upper warm air and a considerable area below the fans is warmed in this way. The use of heater pots to augment this process is a possibility.

Weather Forecasts—Great strides have been made in the accuracy and application of weather forecasts for farmers. The Government Meteorological Office, through the farmers' organisations, and the private Weather Consultants through their own representatives, are doing much to show how the use of weather forecasts pays for itself even on the smallest holding. Hour-to-hour knowledge of oncoming weather, correctly applied, is invaluable. Forecasts of the weather spells expected for the next week or month are a great aid to planning work to the best advantage.

Where to get Weather Forecasts for two to three days ahead—Short range weather forecasts are given on radio and television programmes and are also available from the Air Ministry Meteorological Offices and the more reputable firms of Weather Consultants.

Radio and television forecasts are of least value to the farmer the information being too general and the areas covered too wide.

Air Ministry forecasts cost little or nothing and are therefore within reach of all farmers. Moreover, the large number of out-stations around the country which will give forecasts on demand means that the cost of telephone calls is reduced.

Services supplied by the private Weather Consultants are more specialised. The higher fees charged can be offset against the advantages of having information directly applied to the work in hand, and often pin-pointed for the client's own area. The technicians can take a much greater interest in the individual, obviously an impossibility with a government department run principally by and for the Air Ministry, and having no connection with agriculture.

In many cases the private Weather Consultants will specialise in giving long-range forecasts, the reliability of which is proved by their continued use.

Special services are devised for specific farming operations. For example, during the corn harvest, forecasts are telephoned to the farmer at times specially scheduled to suit his convenience. Forecast details include an estimation of the type of drying day expected, amount of over-night dew, and type, amount and time of the following day's rain. Such forecasts may be issued twice a day.

Services are similarly planned for spring spraying or dusting, irrigation, and the hay harvest.

Where to get Long-range Weather Forecasts—These may be obtained from several sources. One leading weekly newspaper for farmers carries a special 7-day Outlook designed for farmers and covering specific areas of the country. A firm of Weather Consultants in London with American affiliations, provides 7-day Outlooks, 30-day Monthly Trends and 90-day Seasonal Predictions. These forecasts are based upon methods developed and utilised by the Allied armies during the war.

Long range forecasts are not issued by the Air Ministry.

How to get Air Ministry Weather Forecasts—Short range weather forecasts are available without charge from the Air Ministry Meteorological Office. The forecasts provided are, broadly speaking, 24-hour forecasts for land areas and coastal sea areas of the British Isles, with an indication wherever possible of the Outlook for the following day or two.

Anyone in the Greater London area can obtain the current forecast for that area, and also information about the existing state of the weather by ringing up the Meteorological Office, Kingsway, HOLborn 3434, Ext. 629, at any time of day or night, or by pre-paid telegram addressed to WEATHER WIRE, LONDON. Similarly, local forecasts and weather information can be obtained between 9 a.m. and 5 p.m. on Mondays to Fridays and from 9 a.m. to 1 p.m. on Saturdays, at the following Meteorological Office forecasting centres in the provinces.

Meteorological Office	Telephone Number
Abingdon (Berkshire) ...	Abingdon 288, Ext. 121, 209
Aldergrove (Northern Ireland)	Antrim 2202, Ext. 125, 126, 127
Bawtry (Yorkshire)	Bawtry 363–7, Ext. 111, 45.
Eastleigh (Southampton) ...	Eastleigh 87228–9, Ext. 10, 6, 8
Gloucester	Gloucester 24465–6–7, Ext. 109, 113
Inverness (Raigmore) ...	Inverness 1853–8, Ext. 61, 65
Mildenhall (Suffolk)	Newmarket 3151, Ext. 15, 25
Pitreavie (Fife)	Inverkeithing 264–7, Ext. 118, 119
Plymouth (Devonshire) ...	Plymstock 2224, Ext. 108, 109
Preston (Lancashire)	Preston 4602, Ext. 203
Prestwick (Ayrshire)	Prestwick 7256, Ext. 58
Shawbury (Shropshire) ...	Shawbury 351
Speke (Liverpool)	Garston 1240, Ext. 20–22
Upavon (Wiltshire)	Upavon 7–8, Ext. 8, 9
Watnall (Notts)	Nottingham 45731, Ext. 230, 231

Consultants—Both short and long range weather forecasts may be obtained at a fee from the more reputable firms of Weather Consultants.

Of these, the foremost in Europe is International Meteorological Consultant Services Ltd. (IMCOS Ltd.), 200 High Holborn, London, W.C.1. Tel : HOLborn 2675.

Weather Lore

Some of the " rules-of-thumb " country weather prophecies are reliable and, in fact, resemble some of the scientific forecasters' laws—with slight modifications.

" Rain before seven, fine at eleven " is many times right. Rain belts crossing the country conform to fairly standard dimensions and speeds. Most rain belts will clear the observer within four hours.

" Red sky at night, shepherds delight, etc." may be correct three or four times out of five, at least in respect of the first part of the saying. The atmospheric conditions which give a red sky late in the day happen to be those favourable to a spell of fine weather. The last half of the saying is rather more doubtful.

" Ring round the moon, rain soon" is also supported scientifically. The approach of a depression or of a rain belt is heralded very often by a high thin cloud sheet which gradually thickens and lowers. This cloud is composed of ice crystals which refract the moon's (or sun's) rays into a halo of light some distance from the source of light. The halo disappears as the Cirrhus cloud thickens into Altostratus and Nimbus. It is misleading to say that the halo always precedes rain, but there is more risk of rain after the halo is seen than before and this probability is greatest in winter.

Sometimes this high (30,000 feet up) Cirrhus cloud does not take the form of a thin sheet, but is blown into the shape of " mares tails," easily visible. Hence the saying, often true :

" Trace in the sky the painters brush ;
The winds around you soon will rush."

The cirrhus cloud may less commonly be composed of small white flakes or globules in the form of " mackerel sky." The associated rule is not too reliable. This cloud usually comes after a depression (which gives rain) when it is difficult to assess just what sort of weather is coming along without more scientific aids. The cloud also forms during thundery weather which characteristically is " not long wet, not long dry."

Stratus, low grey cloud, in hilly country is a sign that the air is becoming moist, which in turn suggests rain. Hence most hilly counties in this country have local sayings such as that from Worcestershire :

" When Bredon Hill puts on his cap,
Ye man of the vale beware of that."

Weather lore based on winds alone is much less reliable. A wide variety of weather can occur with any given wind. Where cloud and wind are given together the saying is much more likely to be correct.

But the failing of men to seize upon coincidences and magnify them into rules cannot be avoided.

It is said that there is a frost in May for every fog in March. The records show that on average, there are nearer two frosts in May to every fog in March. And lest this become weather lore it is stressed that this is an average ratio for a number of years. The proportion of fogs to frosts in each year examined was different.

Does " A new moon bring fine weather " ? This little bit of confidence trickery no doubt arises from the fact that to see the new moon at all, a fine night is needed. If the moon is a little older than it ought to be when the fine night arrives, the casual observer will see no difference.

Forecasters who base their predictions upon the phases of the moon should be given a wide berth. On average our weather changes every few days and such changes are bound to coincide at times with the changes of the moon occurring every seven days.

The old belief that if the wind is in a cold quarter on March 21st it will remain in that quarter for three months (with correspondingly cold weather) has no basis in fact. The wind, is never as constant as this.

SOILS

Formation of Soil—The inorganic constituents of soils have their origin in the rocks of the earth's crust of which the commonest may be classified thus :—

Igneous	*Sedimentary*	*Metamorphic*
Granite	Sandstones	Schist
Syenite	Shales	Gneiss
Diorite	Conglomerates	Slate
Gabbro	Dolomite	Marble
Peridotite	Limestones	Quartzite

When exposed to atmospheric agencies weathering occurs and the rhegolith is formed. Weathering is of two main types : (*a*) physical, and (*b*) chemical. The former may be regarded as disintegration and the latter as decomposition.

Classification of Weathering Processes. PHYSICAL—

(*a*) Temperature—differential expansion and contraction of minerals, frost action, exfoliation.

(*b*) Erosion and deposition by moving water, ice and wind.

(*c*) Biological—action of plants and animals.

CHEMICAL—(*a*) Hydrolysis ; (*b*) Hydration ; (*c*) Carbonation ; (*d*) Oxidation ; (*e*) Solution.

Physical Weathering—Differential expansion and contraction of rock minerals, produced by marked temperature changes, set up strains within the rock which result in cracking. The force developed by water present in the joints and fissures of rocks which expands on freezing produces similar disintegrating effects. Rocks may be also affected by the action of moving water, moving ice (glaciers) and wind. Plant roots, particularly those of trees, may assist by extending the cracks in rocks.

Chemical Weathering—The chemical constituents of rocks may be grouped as follows :—

Strong bases : Na_2O, K_2O, CaO, MgO.

Weak bases or Sesquioxides : Fe_2O_3, Al_2O_3.

Silica or Silicon dioxide : SiO_2.

Chemical weathering accompanies physical weathering and results in decomposition of the rock material. It depends on the decomposing action of water charged with carbon dioxide and, possibly, organic acids formed from the decay of vegetable matter.

Hydrolysis is a double decomposition ; water reacts with and removes the strong bases from combination producing hydroxides. As the water contains dissolved carbon dioxide, carbonation occurs, i.e., the hydroxides are rapidly changed into carbonates.

Hydration—the taking up of water—increases the volume and softens the rocks so that they are more readily affected by physical and chemical forces. Oxidative processes may affect the hardness and increase the volume of some rock materials. Because of the presence of water, solution occurs and soluble salts of such elements as sodium, potassium, calcium, magnesium, etc., are found in the water which issues from rocks.

Classification of Soil Materials—The weathered soil material, in the absence of agencies of transportation, tends to accumulate and protect the subjacent rock from weathering action. Since the upper layers of soil material are continually acted upon by mechanical forces two groups of materials can be distinguished.

(i) Sedentary	*in situ*	Inorganic	Residual
		Organic	Cumulose
(ii) Transported	Gravity		Colluvial
	Water		Alluvial Marine Lacustrine
	Ice		Glacial
	Wind		Aeolian

Residual material has usually undergone extensive weathering and, in humid regions, is well oxidised and intensely leached. In cool dry climates, where weathering is less severe and chemical decomposition takes place more slowly, leaching is less intense and the base status of the residual material is higher.

Cumulose materials are accumulations of organic matter in lakes, ponds and swamps formed by the decay of plants. Examination of these deposits shows the successive transition from the lower hydrophytes such as sphagnum to the higher shrubs and trees. They contain, in addition, varying amounts of mineral matter such as silt and clay.

Colluvial materials have been moved from position by gravity, as in the case of rock debris or talus at the foot of slopes. Movement is accelerated by cultivation and assisted by frost action. Typical soil material is coarse and stony because of the predominance of physical weathering.

Movement of weathered material by rivers results in the formation of alluvial deposits, such as flood plains and river terraces. Some weathered material is deposited as sub-aqueous or lacustrine deposits while some eventually reaches the sea to form deltas. The type of material deposited depends upon the velocity of the water by which it is borne. Hence coarse sediments are the first to be dropped, while finer material is carried further.

The material transported by moving ice is termed glacial till or boulder clay. With it are associated bedded sands and gravels formed from material which has been re-sorted by water following the melting of the glacier. Other stratified deposits are eskers while drumlins and kames are usually composed of unassorted till.

Wind is responsible for carrying and depositing fine grained (fine sand or silt) material. Examples of such windborne deposits are coastal sand dunes and loess.

The establishment of micro-organisms and the higher plants and the accumulation of organic residues marks the beginning of the transition from soil material to soil. Thus the formation of soil is a biochemical process.

Soils derived from the weathering of igneous rocks are called primary soils. While the same physical and chemical factors bring about the weathering of sedimentary rocks, the latter have already passed through a cycle of weathering before denudation, transportation and their deposition as sub-aqueous sediments took place. Consequently, the effect of parent material is much more marked and the clay fractions of such soils are richer in SiO_2 than those of primary origin.

The Soil Profile—The vertical section of soil as seen in the sides of a pit is known as the soil profile and the individual layers of which it is composed down to the parent material are called horizons.

Two sets of processes are involved in soil formation: (*a*) Physical and chemical weathering which give rise to the parent material; (*b*) Profile development from the parent material.

Usually the former precedes the latter but they may proceed simultaneously. Soils in which development has been allowed to proceed without disturbance exhibit distinctive profiles, the characters of which are utilised for purposes of soil classification and survey.

The upper layers of soil, generally, contain appreciable amounts of organic matter the accumulation of which produces a darkening of colour; such layers are termed the A horizon. They make up the plough layer, furrow slice or surface soil. This horizon merges into a layer markedly weathered but comparatively free from organic matter and known as the B horizon. At its base the B horizon or subsoil merges into the C horizon or parent material, the upper part of which is often considerably weathered and the base of which passes into the country rock.

Constituents of Soils—The main constituents of soils are : (i) Mineral matter ; (ii) Organic matter ; (iii) Water ; (iv) Air.

The mineral matter or more solid phase consists of rock fragments in various stages of decomposition which have been formed by physical and chemical weathering. Intimately mixed with this inorganic material is organic matter, an accumulation of vegetable and animal residues in an active state of decay. In a particular soil the amount of this material varies with the horizon. The organic matter may consist of recognisable remains of plants but much of it is present as a dark coloured amorphous substance called humus (or humified organic matter). The amount of organic matter in soils varies widely but, in British agricultural soils it is commonly about 8–10 per cent. Occurring between large solid particles and within and between clusters of small particles (aggregates) are pores of variable size which are occupied by water and air. The amount of these components is governed by the mineral and organic matter.

Mineral Matter. ROCK-FORMING MINERALS—Relative proportions of the ten most important rock forming minerals in the earth's crust are :—

	Per cent.
Felspar	48
Quartz	36
Mica	10
Limestone and Magnesian Limestone ...	2
Hornblende Augite	1
Olivine and Serpentine	1
Clays	1
Other minerals	1

Composition of the Principal Minerals found in Soils.

FELSPARS—Chemically they are aluminium silicates with varying amounts of silicates of potassium, sodium and calcium. The three principal types are :—

(i) Orthoclase—potassium aluminium silicate—
$K_2O.Al_2O_3.6\ SiO_2$

(ii) Albite—sodium aluminium silicate—$Na_2O.Al_2O_3.6SiO_2$

(iii) Anorthite—calcium aluminium silicate—
$CaO.Al_2O_3.6\ SiO_2$

QUARTZ—Silicon dioxide—SiO_2 is found in all crystalline rocks. It occurs also as sand and is the principal constituent of granite and sandstones.

Micas—In chemical composition the micas are silicates of aluminium and potassium with silicates of iron, magnesium and sodium. The principal micas are :—

(i) Muscovite—white mica—potassium aluminium silicate—$K_2O.3Al_2O_3.6SiO_2.2H_2O$.

(ii) Biotite—black mica—iron magnesium silicate—with potassium and aluminium.

Calcium carbonate—calcium and magnesium carbonate—$CaCO_3$, $MgCO_3$—occur in massive form in the Carboniferous limestone and Chalk formations and with magnesium carbonate as dolomite chiefly in the Permian. The percentage composition of true dolomite is : $CaCO_3$, 54·35 ; $MgCO_3$, 45·65, although the term is often loosely used to denote traces of $MgCO_3$ in limestones.

Hornblende—silicate of calcium, magnesium and iron with sodium silicate with the probable formula $CaO\ 3(Mg.Fe)O.4SiO_2.Na_2O.Al_2O_3\ 4SiO_2$.

Augite—silicate of calcium, magnesium, iron and aluminium with variable composition probably represented by the formula $CaMg(SiO_3)_2\ (Mg.Fe)\ (Al.Fe)_2\ SiO_6$. These minerals occur in basalt as black or greenish-black crystals.

Olivine and serpentine—Olivine is a ferro-magnesian silicate with the formula $2(Mg.Fe)O.SiO_2$. On the assumption of water (hydration) serpentine, hydrated magnesium silicate, is formed. It has the composition $3MgO.2SiO_2.2H_2O$.

Clays—result from weathering of rocks chiefly of igneous origin and possess the properties of becoming plastic when wet in which state they can be moulded, and of hardening when fired. They usually contain iron oxide and carbonaceous matter, materials which confer colour and affect their economic value in the pottery industry, together with varying amounts of quartz, felspar and mica. Chemically, clays are hydrated aluminium silicates with the general formula $Al_2O_3\ x\ SiO_2.nH_2O$ and may contain variable amounts of calcium, magnesium, sodium, iron, etc.

Other minerals which occur in the soil are :—

Tourmaline—a borosilicate of aluminium with alkali metals and iron or magnesium. Its composition is represented by the formula $R_9Al_3(B.O\ H.)_2Si_4O_{19}$ where R may be H, Na, K, Li, Fe or Mg. It occurs in the more acid rocks, e.g., granite and syenite as an accessory mineral.

Rutile—titanium oxide (TiO_2) which occurs as an accessory component of igneous rocks such as granite, diorite and gabbro.

Zircon—Zirconium silicate ($ZrO_2.SiO_2$), is widely distributed in acid igneous rocks such as granite and in metamorphic rocks such as crystalline limetones and gneiss.

GLAUCONITE is a hydrated silicate of iron and potassium with, possibly, aluminium, magnesium and calcium. It is found in sedimentary rocks particularly of Cretaceous age and especially in the Greensand.

OXIDES OF IRON—Magnetite ($FeO.Fe_2O_3$) is a mixture of two oxides of iron. It is a constituent of most igneous rocks, chiefly of a basic nature, and of metamorphic rocks.

HEMATITE (Fe_2O_3)—generally occurs in pockets and hollows replacing limestone although some deposits have developed by the alteration of iron silicates and carbonates of sedimentary origin.

The hydration of hematite results in the formation of limonite ; it is accompanied by a progressive colour change from red to yellow.

Hematite (red)		Fe_2O_3
Limonite Group (yellow)	Turgite	$Fe_2O_3.\frac{1}{2}H_2O$
	Goethite	$Fe_2O_3.H_2O$
	Limonite	$Fe_2O_3.1\frac{1}{2}H_2O$
	Xanthosiderite	$Fe_2O_3.2H_2O$
	Limnite	$Fe_2O_3.3H_2O$

Composition of the Mineral Particles—Of the various minerals occurring in soils quartz is by far the commonest and it accounts for from 60 to 90 per cent of the sand fraction even in clay soils. The sand particles in soils formed from sedimentary rocks may contain 85–95 per cent. SiO_2, i.e., sand is impure silica. In clay particles the proportion of SiO_2 is of the order of 50 per cent. Clay is silicate containing in addition to silica about 35–40 per cent. Al_2O_3 and 4–7 per cent. K_2O and other bases. In the sand fraction of Palæozoic soils of Scotland and North Wales there is much undecomposed silicate with frequently not more than 60 per cent. SiO_2.

THE CLAY FRACTION—As the mineral particles become finer the rock minerals tend to disappear to be replaced by their decomposition products which take the form of new minerals relatively stable under soil conditions. These minerals are more reactive than the rock minerals and can take part in base exchange (see page 29).

Clay particles are of a crystalline nature composed of layers of hydrated alumina and silica linked by oxygen atoms.

The clay minerals present in soil fall into the following groups :

KAOLIN GROUP ($Al_2O_3.SiO_2.xH_2O$)—(*a*) Kaolinite ; (*b*) Anauxite ; (*c*) Halloysite.

The crystal lattice of this group of minerals consists of one sheet of silica atoms to one of alumina. They have a low base exchange capacity and little power to absorb water.

MONTMORILLONITE GROUP—(*a*) Montmorillonite ; (*b*) Pyrophyllite ; (*c*) Beidellite ; (*d*) Nontronite.

The physical and chemical properties of this group of minerals are quite distinct from those of the Kaolin group. They possess units of two layers of silica to one of alumina, and their expanding lattices permit of a high degree of hydration and cation adsorption.

In addition to these secondary also contains in varying amounts free oxides of iron and titanium, etc., alumina, silica and micas.

Organic Matter—Soil is differentiated from rock debris by the presence of organic matter which originates in complex organic compounds synthesised by plants from carbon dioxide.

Under virgin conditions increments of organic matter take the form of plant and animal remains while in agricultural practice it is added to by the above-ground crop residues, crop roots and applied plant and animal materials.

Composition of Organic Matter—The composition of fresh organic matter, i.e., of crops grown for green manuring is probably as follows :—

		Per cent.	
	Moisture	75	
	*Dry matter ...	25	
			100 per cent.
*Containing	Carbon	11	
	Oxygen	10	
	Hydrogen	2	
	Ash	2	
			25 per cent.

In addition small amounts of nitrogen, sulphur, phosphorus and other elements are present.

The composition of plant materials varies greatly with species and within a species. Leguminous crops have higher nitrogen contents than straw and roots which are rich in carbonaceous matter.

The amount of organic matter present varies with the type of soil and the system of management. The following figures, while illustrating this variation, cannot be regarded as average amounts.

	Percentage of dry weight of soil
Upland soil	2
Cultivated soil (agriculture)	8–10
Cultivated soil (horticulture)	15
Peat	90–95

In general there is a gradual decrease in the amount of organic matter in the soil from the surface downwards.

Soil Micro-organisms—The decomposition of organic matter may take place by purely chemical means but usually the process is assisted by the activities of micro-organisms. These micro-organisms may be classified thus :—

Micro-fauna—(i) Protozoa ; (ii) Nematodes ; (iii) Worms ; (iv) Insects.

Micro-flora—(i) Algæ and diatoms ; (ii) Fungi, actinomyces ; (iii) Bacteria.

Soil bacteria, the numbers of which have been variously estimated at from 2–200 millions per gram of soil, are numerically superior to the other groups of micro-organisms. They may be grouped as follows :—

Heterotrophic Organisms—(i) Nitrogen-fixing bacteria (free-living or symbiotic) ; (ii) Ammonifying bacteria ; (iii) Cellulose splitting bacteria.

Autotrophic Organisms—(i) Nitrifying bacteria ; (ii) Sulphur bacteria ; (iii) Iron bacteria.

The former group derive energy and carbon for growth from the oxidation of complex organic compounds. They include organisms which utilise atmospheric nitrogen to build up body protein. Autotrophic organisms obtain energy from the oxidation of inorganic compounds and carbon from carbon dioxide. In this group are organisms with specific functions, e.g., nitrosomonas which oxidises ammonia to nitrite and nitrobacter which oxidises nitrite to nitrate.

Decomposition of Organic Matter—In addition to fresh green materials, soil organic matter consists of fœcal and plant residues.

The rate of decomposition varies with the age and maturity of the organic material. Compared with fresh material—plant residues, of which the chief constituents are structural carbohydrates with small amounts of proteins, waxes, etc., are with difficulty decomposed.

Carbon dioxide and water are the end products of the simplification of the carbohydrate material while amino-acids and ammonia result from the breakdown of the nitrogenous part. Not all the carbohydrate and protein are completely oxidised but reach a stage at which a complex colloidal material known as *humus* is produced.

The decomposition of organic matter is essentially an oxidative process. Soils which absorb the greatest amount of oxygen and produce the greatest amount of carbon dioxide in a given time are, it has been suggested, of higher fertility than those in which oxygen absorption is less, but while this may be true in similar soils under similar conditions generalisation is impossible.

Carbon : Nitrogen Ratio of Soil Organic Matter—The ratio of carbon to nitrogen in materials such as cereal straws, added to the soil as unharvested residues, is of the order of 40 : 1. Leguminous residues have narrower ratios because of their higher nitrogen content. The C : N ratio of cultivated soils of temperate regions is 10–12 : 1 and, since the amount of unaltered plant residues in the soil is small, the ratio approximately represents that of the soil humus.

When additions of organic matter with C : N ratios greater than that for the soil are made, carbon dioxide is evolved, due to increasing activity on the part of micro-organisms. The micro-organisms which bring about the simplification of organic matter require supplies of nitrogenous compounds for elaboration into body substances and these supplies are taken from the soil. Consequently a temporary reduction in the amount of ammoniacal and nitrate nitrogen present in the soil results.

The Composition and Properties of Humus—The average composition of humus is :—

	Per cent.
Carbon	50
Oxygen	35
Nitrogen	5
Hydrogen	5
Ash	5

and it varies very little from these figures from whatever source it should be obtained.

In the formation of humus, lignin is probably the most prominent plant constituent. It is associated with protein to form a ligno-proteinate, i.e., a lignin-protein complex which is relatively stable in the soil and which is known as the humus-nucleus.

While not a distinct chemical compound of fixed composition humus possesses definite chemical properties, e.g., it exhibits acidic and base-exchange properties and can thus form salts (which are electrolytes) and take part in cation exchange reactions.

Because of its colloidal nature and high internal surface it possesses in a high degree the property of adsorption of gases. In addition, when it absorbs water, the absorption is accompanied by a marked increase in volume ; when it dries out shrinkage occurs.

Effects of Organic Matter on the Soil—Undecomposed organic matter has a beneficial opening effect on heavy soils ; on light soils the effect of applications of unhumified material is to increase their open texture with detrimental results.

Hence the respective values of "long" and "short" farm manure to heavy and light soils.

Humus is associated with colloidal clay in the development of that condition of granulation or aggregation of soil particles known as a "crumb structure."

Because of its colloidal nature humus can hold sand particles together and, with its capacity to absorb water, it thus gives body to light soils and increases their water holding capacity. In the absence of calcium humus may aggravate the water relationships of heavy soils; with calcium, humus assists in aggregate or crumb formation in such soils, and thereby improves drainage.

By its intimate distribution in soils, and especially as a coating over the particles, humus confers a dark colour on the soil. This has the effect (see page 37) of raising its spring temperature with subsequent beneficial effects on crop germination and growth.

In addition organic matter acts as a source of energy for soil organisms and its decomposition products provide nitrogen, phosphorus, potassium, sulphur, etc., as simple compounds for plant nutrition.

Colloids—A substance is regarded as being in the colloidal state if its particles, of size between 1 and 100m*u*, are dispersed throughout a continuous medium. They are intermediate between molecular or ionic solutions in which particles of the solute cannot be seen by the naked eye and coarse suspensions or emulsions in which particles, visible by eye or with a microscope, are dispersed throughout a liquid.

TABLE 1

SIZE OF PARTICLES

Name	Diameter limits	Visibility
Microns	200 m*u*	With microscope.
Sub-microns ...	200–5 m*u*	With ultramicroscope.
Amicrons	<5 m*u*	—

u—0·001 mm.
m*u*—0·000001 mm.

Properties of Colloids—Colloids have pronounced adsorptive properties by reason of their high specific surface and surface activity predominates over chemical activity.

Certain colloids known as hydrophobic colloids have no affinity for water and consequently may be easily precipitated as gels from the disperse phase. Others, e.g., agar and gelatin have a pronounced affinity for water which they can absorb and into which they may slowly diffuse. Such colloids, known as hydrophilic colloids, may be able to increase the stability of disperse systems of hydrophobic colloids.

In a colloidal solution, or " sol," the particles are in a state of rapid Brownian movement but on the the addition of certain electrolytes there is a cessation of movement and the particles aggregate or flocculate to form a " gel."

Colloidal electrolytes, of which clay and humus are examples, possess one polyvalent ion of colloidal dimensions with a corresponding number of simple ions of opposite sign. In their reactions clay and humus particles behave as polyvalent anions with a large number of cations attached.

Properties of Colloidal Clay—Some idea of the infinitesimal size of colloidal particles and the immense surface they expose is given by the fact that a cubic foot (80 lb.) of colloidal particles offers a total surface area of about 150 acres.

Colloidal clay also occurs in intimate association with soil organic matter, has a high water absorptive capacity and thus confers on soils a high water-holding capacity. The release or assumption of water is accompanied by changes in volume; thus a clay soil shrinks on drying. Plasticity, and cohesion, are further properties controlled by the colloidal phase. It is sensitive to small quantities of electrolytes.

Flocculation of Soil Particles—In general neutral salts of such bases as sodium, potassium and ammonium produce flocculation of particles in suspensions of calcium-free silt or clay while the hydroxides will not. A similar result is obtained with calcium hydroxide and neutral calcium salts in silt suspensions but in clay suspensions flocculation is brought about better by the hydroxide. Under the conditions of alkalinity obtaining in the presence of calcium hydroxide the gelatinous and siliceous surface of colloidal clay forms a coagulum with calcium which more than balances the deflocculating effect of the hydroxide on the particles.

Ionic Exchange—Colloidal particles are regarded as possessing an inner shell of negative charges (anions) and an outer diffuse layer of positive charges (cations) which, although tethered to the particles, are free under certain conditions to exchange places with other cations.

Owing to the presence of water in and around the colloidal particles some of the materials present may be either in solution or in a mobile, reactive state. The cations are capable of being instantaneously exchanged by others, the order of replacement being H > Ca > Mg > K > Na.

In other words hydrogen ions (H^+H^+) and calcium ions (Ca^{++}) are the most active. The exchange takes place on a basis of chemical equivalents and is practically unaffected by temperature. Cationic (base) exchange reactions are usually reversible, and the absorbed cations greatly affect the physical properties of soils. These factors are of great importance in soil management.

There is an upper limit to the capacity of a soil for exchangeable bases at which point the soil is said to be base-saturated, i.e., the base exchange capacity of the soil has been satisfied. Under agricultural conditions this most frequently happens when a soil has long been in equilibrium with calcium carbonate. In the absence of calcium carbonate the amount of exchangeable bases held by a given weight of soil may fall below the saturation point and the soil is described as base-unsaturated. Such a condition can arise when a soil has been leached by the percolation of water containing dissolved carbon dioxide.

In normal soils the cations Ca, Mg, K and Na occur in the following proportions :—

Ca	Mg	K	Na
79	13	2	6

When hydrogen ions displace calcium ions the colloidal particles tend to become acid by reason of the hydrogen gained. Thus acid soils, i.e., soils which have been leached, have their base exchange capacity largely satisfied by hydrogen The colloidal complex of soils which have been inundated with sea water for a short time becomes saturated with sodium ions with the result that the soil becomes sticky. Reclamation consists in replacing the sodium with a neutral calcium salt such as gypsum.

Physical Properties of Soils – Factors which influence the physical properties of soils include the type and size distribution of the non-colloidal particles, the character and content of the colloidal matter, their structure and their moisture content. The character of the colloidal matter is closely related to the respective amounts of inorganic and organic colloids and the content of adsorbed bases.

Mineral Matter—The mineral matter consists of particles of varying sizes which may be classified thus :—

(1) Very coarse	Visible to naked eye	Stone and gravel.
(2) Coarse	Visible to naked eye	Sands of various sizes.
(3) Fine	Visible under microscope	Silt particles.
(4) Very fine	Visible under electron microscope	Clay (colloidal).

The relative proportions in which the particles of different sizes occur is of significance and is determined by mechanical analysis.

The size of particles as distinguished by the International Society of Soil Science is as follows :—

	Fraction	Diameter limits (mm)
	Stones	greater than 2·000
Fine earth	Coarse sand	2·000–0·200
	Fine sand	0·200–0·020
	Silt	0·020–0·002
	Clay	less than 0·002

The mechanical composition of a soil provides an estimate of its texture.

TABLE 2

MECHANICAL ANALYSIS OF SOME TYPICAL SOILS

Percentage of 2 mm. soil dried at 105°C.

Fractions dried at 105°C.

Fraction	TEXTURE (see page 32)						
	Sa	Sb	La	Lm	Lb	Z	C
Coarse sand	4·08	49·09	32·47	12·64	3·38	6·22	0·08
Fine sand ...	73·19	30·71	22·67	23·15	13·67	16·50	0·74
Silt	7·25	7·30	21·45	19·65	32·55	52·01	21·64
Clay... ...	4·10	10·65	13·95	17·93	37·13	19·28	70·01
$CaCO_3$ ...	6·76	nil	4·99	20·90	8·11	0·09	1·96
Loss on ignition	3·33	2·54	3·68	4·42	6·08	4·50	5·67
Loss by solution	0·26	0·60	1·29	0·85	0·51	0·90	0·94
	98·97	100·89	100·50	99·54	101·43	99·50	100·44

Textural Classification of Soils—The textural classification of a soil, following mechanical analysis, may be obtained by the use of triangular co-ordinates, a method devised by the United States Department of Agriculture.

Textural Names of Soils—The following texture groups and classes are recognised in the respective countries :—

United States of America		Great Britain	
Class	Group	Class	Symbol
Gravelly sands ...	Sandy soils	Light sand	Sa
Coarse sands ...		Heavy sand	Sb
Medium sands ...			
Fine sands			
Very fine sands ...			
Loamy sands ...			
Stony sandy loams	Loamy soils	Sandy loam	La
Gravelly sandy loams		Loam	Lm
Coarse sandy loams		Heavy loam	Lb
Medium sandy loams			
Fine sandy loams ...			
Very fine sandy loams			
Loams, gravelly loams, stony loams			
Silty loams and stony silt loams ...	Silty soils	Light silt	Za
Silty clay loams ...		Silt	Zm
		Clay silt	Zb
Clay loams and stony clay loams	Clay soils	Clay	C
Stony clays ...			
Gravelly clays ...			
Sandy clays ...			
Silty clays			
Clays			

The British system of classifying soil texture may be expande as required.

In the cases of sands and clays the dominant mineral fractic gives its name to the soil texture group but in the case of loan predominance cannot be assigned to any one particle size sin all are represented.

Number of Particles—The number of particles per gra clearly varies with particle size and may be calculated usi the average diameter of the particle in each size group. the following table the numbers of particles per gram soil under different conditions have been estimated.

TABLE 3

No. of Particles × 10^6

Market garden	1,955
Small fruit	3,955
Wheat	10,228
Grass and wheat	14,735
Limestone	19,638

Internal Surface of Soils—The total surface of all particles per unit weight of soil is its internal surface. On the assumption that all particles are spherical the internal surface may be calculated from the mechanical analysis using the average diameter of the particles in each soil group. The following table presents certain estimations made in the United States of America :—

TABLE 4

Soils	Internal Surface per c/ft.	
	Sq. ft.	Acres
Dune sand	30,310	0·696
Brown sandy loam (prairie)	55,380	1·271
Yellow-gray silt loam (timber)	69,780	1·602
Brown silt loam (prairie)	70,900	1·628
Black clay loam (prairie)	81,780	1·877
Drab clay (often timbered)	136,700	3·138

True and Apparent Density—The true density (T) is a function of the individual densities of the soil constituents to which each contributes its proportionate share. The apparent density (A) is the density of the soil as a whole, i.e., of particles and pore space.

TABLE 5

DENSITIES OF VARIOUS SOIL CONSTITUENTS

Quartz	2·6 –2·7	Muscovite	2·76–3·1
Orthoclase	2·54–2·57	Biotite	2·8 –3·2
Albite	2·6	Chlorite	2·6 –2·96
Oligoclase	2·65	Hematite	4·9 –5·3
Anorthite	2·76	Limonite	3·6 –4·0
Amphiboles and Pyroxenes	2·9 –3·6	Clay	2·6 –2·7
		Apatite	3·16–3·22
Olivine	3·2 –3·5	Magnetite	4·9 –5·2

It will be seen from the above table that the densities of the principal soil constituents, with the exceptions of magnetite 4·9–5·2) and organic matter (1·2–1·7) fall within a narrow range. The true density therefore largely depends on the relative proportions of organic and inorganic matter present.

The weight per unit volume of dry soil is the apparent density and in this determination air or pore space is included in the volume. Hence the apparent density is represented by a lower figure than that for true density.

Pore Space—The relationship between the true and apparent densities and the pore space (P) may be represented thus :—

$$P = \frac{T - A}{T}$$

and expressed as a percentage.

The pore space in soils rarely exceeds 50 per cent. or falls below 30 per cent. It depends upon the size, shape and degree of compaction of the soil particles and their state of aggregation, e.g., into crumbs. It may be increased by additions of organic matter.

The following table indicates the approximate percentage pore space over a wide textural range :—

TABLE 6

	Pore space per cent.
Sands	30
Light loam	35
Medium loam	40
Heavy loam	45
Clay loam	47–50
Clay	50

Although clays possess a greater total porosity than sand the pore spaces in the latter, due to their greater volume, ar more conducive to good drainage and aeration. Thus th advantage of aggregation of soil particles is that the increas in proportion of macro-pore space to micro-pore space lead to better drainage and aeration.

Pore space may be increased by harrowing and decreased b rolling, trampling by stock or any treatment whic results in the destruction of aggregates, e.g., by the use c deflocculating agents.

The soil is a three-phase system—consisting of solids, i.e mineral and organic matter, with liquids and gases as depender variables occupying the pore spaces. Little variation take place in the solid phase but the proportion of solids to liquic and gases is constantly changing. Thus as water is lost b transpiration, evaporation and drainage the proportion gas increases while air may be displaced by increments of water in the form of heavy rain.

Plasticity—The property of plasticity, which is largely due to the mineral colloidal material present, is the ability of a moist soil to change its shape in response to an applied force. With the presence of increasing amounts of water the soil becomes more and more plastic until the upper limit is reached after which a thin suspension is produced. At the lower limit of plasticity a soil would break down and crumble due to its inability to change shape under the influence of applied stress.

Plastic soils are cohesive, hence soils which are capable of being moulded set into hard clods on drying.

Soil Structure—Structure is the consequence of the aggregation of primary soil particles into compound aggregates although certain types recognised are of the single-grain type. For plant growth the crumb or granular structures are required.

Soil structure is affected by :—

(i) Growing plants (*a*) through their residues as organic matter ; (*b*) by their root activity ; (*c*) by the protection provided against impact of rain.

(ii) Adsorbed cations, lime having the ability to flocculate the soil colloids whereas sodium is a deflocculant.

(iii) Activities of fungi—the mycelial threads of which have a temporary binding effect on soil particles.

(iv) Bacteria—due to the secreted mucuous which also exerts a binding effect which may be temporary or permanent depending on the type of gum secreted.

Soil Temperature—The mean soil temperature closely approximates the mean air temperature throughout the year although there may be wide seasonal and diurnal fluctuations according to the distance below the surface.

The specific heat of soil is of importance for on it depends the response of a given soil to additions or losses of heat by radiation and of losses by vaporisation from wet soils. The following table (Mitscherlich—in G. W. Robinson's Soils, p. 241)

TABLE 7

Soil	Volume specific heat in cal./c.c. at varying degree of saturation		
	Dry	50 per cent. Saturated	Saturated
Sand	0·302	0·510	0·717
Humus	0·148	0·525	0·902
Clay...	0·240	0·532	0·823

shows some variations in the specific heat of dry soils with greater variations in that of wet soils owing to the high specific heat of water (Sp. Ht = 1) and the greater amount of water required to saturate clay and humus soils.

In consequence moist soils respond more slowly to solar radiation—the only important direct source of heat to the soil—than dry soils and on them plant growth commences later in the spring.

Temperatures required for Germination—The following table (Haberlandt F., Landw. Vers. St., Vol. 17, pp. 104–116, 1874, in "Soils and Soil Management"—Gustafson) indicates the requisite temperatures for germination.

TABLE 8

Crop Seeds	°F		
	Minimum	Optimum	Maximum
Peas, wheat, barley ...	32–40	77–88	100
Corn (maize)	40–51	88–100	111–122
Red clover	32–40	77–100	100–111
Turnip	32–40	77–88	88–100
Mustard	32–40	61–88	88–100
Oats...	32–40	77	88–100
Melon	60–65	88–100	111–122

From the above data it is clear that, with the exception of maize and melons, all the crops listed are capable of germination at low temperatures.

That the temperatures required for growth are similar is seen in the following data presented by A. D. Hall.

TABLE 9

Crop	Temperatures required for growth °F		
	Minimum	Optimum	Maximum
Mustard	32	81·0	99·0
Barley	41	83·6	99·8
Wheat	41	83·6	108·5
Corn (maize)	49	93·6	115·0
Melon	65	91·4	111·0

Farming practice has, in fact, long taken into account the temperature requirements of seeds and crops with the result that frost sensitive crops are not planted in cold soils.

Factors Affecting Soil Temperature—*The diurnal and seasonal* variations in soil temperature become less marked with increase in depth of the soil. Minor variations are caused by clouds which reduce radiation losses from the soil and by winds which, inducing an increased rate of evaporation of moisture, produce a cooling effect.

The site, slope and aspect are further factors which influence soil temperature, e.g., air temperature decreases by 1° F. for every 300 ft. increase in altitude ; in the northern hemisphere southerly slopes are warmer than northerly slopes since they receive more direct insolation.

Dark colours absorb heat better than light colours and dark coloured or red soils similarly absorb more heat in sunshine than do light-coloured soils. The effect on plants is to increase the rates of germination and growth. The following table shows this :—

TABLE 10

EFFECT OF COLOUR OF SOIL ON ABSORPTION OF HEAT

	Depth below surface of soil					
	1 in.		2 in.		3 in.	
	Light	Dark	Light	Dark	Light	Dark
6 a.m.	48·8	50·0	47·5	49·0	48·5	50·5
Maximum reached	71·5	82·0	70·8	78·5	71·3	78·4
Rise in temperature	22·7	32·0	23·3	29·5	22·8	27·9
Gain for dark surface	—	9·3	—	6·2	—	5·1
6 p.m.	66·5	71·5	70·0	74·5	71·0	77·0

(J. G. Mosier and A. F. Gustafson, "Soil Physics and Management.")

Thermal conductivity is increased by compaction and the presence of water, which is a relatively good conductor, in the fine pores. Because of the insulating effect of air in the pore spaces, loose dry soils conduct heat slowly. Finally the water content of the soil influences soil temperature. Thus the high specific heat of wet soils which necessitates a greater quantity of heat to bring about marked changes in soil temperature, may be considerably reduced by the removal of excess water by drainage. The effect of drainage is to lower the specific heat of wet soil and reduce the heat lost in the process of evaporation.

Soil Air—The soil air is closely associated with the solid phase in the form of mineral and organic matter and the liquid phase in the form of the soil solution. There is, in the soil, an equilibrium between these three phases and changes in any one phase is accompanied by changes in the other two phases. It is clear therefore that both the volume and the composition of the soil air will be directly influenced by the soil solution and indirectly by the solid phase (in particular by the colloidal matter) due to its effect on the soil solution. Thus there is a constantly shifting equilibrium between these three phases.

TABLE 11

APPROXIMATE COMPOSITION OF DRY SOIL AIR AND DRY ATMOSPHERIC AIR

	Soil Air (per cent.)	Atmospheric Air (per cent.)
Oxygen	20·6	20·99
Nitrogen (etc.)	79·2	78·95
Carbon dioxide	0·2	0·03

(N. M. Comber, H. T. Jones and J. S. Willcox.)

Soil air differs from the atmosphere in containing a much higher proportion of carbon dioxide, having a relative humidity of the order of 100 per cent. (i.e., it is saturated with water vapour). It contains less oxygen ; some is absorbed by the colloidal surface and an appreciable proportion is dissolved in the soil water.

The amount of carbon dioxide present varies with the rate of microbiological decomposition.

TABLE 12

EFFECT OF CROPPING AND MANURE ON CO_2 CONTENT OF SOIL AIR

Treatment	Percentage CO_2 in soil air at different dates				
	May 15th	May 25th	June 10th	July 7th	July 27th
Unmanured fallow ...	0·10	0·07	0·08	0·08	0·09
Manured fallow ...	0·22	0·32	0·17	0·36	0·35
Cropped to wheat ...	0·61	0·32	0·35	0·48	0·30

(E. J. Russell & A. Appleyard—"Journ. Agri. Sci.," 7 : 1-48, 1915)

Since the relative humidity is usually about 100 per cent., conditions are favourable for the growth of fungi, bacteria and other micro-organisms whose activities are chiefly controlled by temperature. The carbon dioxide content rises to a maximum in spring, falls in summer and rises again in autumn although not to the level reached in spring. The rate at which it is produced depends to some extent upon the aeration of the soil, the oxidative decomposition of organic matter being an aerobic process.

The concentration of carbon dioxide in the soil air depends on : (i) Rate at which it is produced by microbiological activity ; (ii) Rate of diffusion from the pore space to the atmosphere. It is temporarily increased by additions of organic matter, by rainfall and root respiration and is temporarily reduced by ploughing (which increases the rate of diffusion) and sudden changes in temperature.

Apart from the air which is free to diffuse, the soil also contains air held by the colloidal matter or dissolved in the soil solution. The composition of the absorbed air is approximately 90 per cent. carbon dioxide and 10 per cent. nitrogen with a trace of oxygen.

Soils and Water Supply—Rain water reaching the soil passes into the subsoil when the absorptive capacity of the surface soil has been satisfied. The former is removed by drainage and the latter by evaporation or transpiration by plants.

TABLE 13

DRAINAGE THROUGH 5 FT. OF UNCROPPED CLAY LOAM

Annual Average for 42 years at Rothamsted Experimental Station (A. D. Hall)

Months	Rainfall (in.)	Drainage (in.)	Drainage as percentage of rainfall
December–February ...	6·77	5·58	82·4
March–May	5·96	2·11	35·4
July–August	7·83	1·82	23·2
September–November	8·29	4·50	54·2
Mean Total ...	28·85	14·01	48·5

It is seen that drainage is greater in December to January when there is little plant growth and evaporation is low than in summer when these factors have maximum effect. The mean annual loss by percolation is roughly 50 per cent. of rainfall. Under cropped soils loss of water by percolation is of the order of 25–30 per cent.

TABLE 14
RAINFALL

Depth of rain (in.) =	c.ft./acre =	Gallons/acre =	Tons/acre
1	3,630	22,635	101·2
4	14,520	90,539	404·8
8	29,040	181,072	809·6
12	43,560	271,619	1214·4

TABLE 15
WATER REQUIREMENTS OF CROPS

(*Water required in lb. for each* 1 *lb. dry matter produced*)

Crop	lb. water
Wheat	507
Oats	614
Barley	539
Beans	728
Peas	800
Red clover	789
Potatoes	448
Sugar beet	377

(L. J. Briggs and J. L. Chantz—" The Water Requirements of Plants," Bur. Plant. Industry, U.S. Dept. Agr. Bull., 285, p. 90, 1913.)

TABLE 16
WATER TRANSPIRED IN TONS/ACRE

Wheat	600	Mangolds	900
Barley	550	Potatoes	450
Turnips	400	Meadow hay	375

Drainage Water—The chief constituents of drainage waters in cool temperate climates are calcium and sodium, the latter being almost completely removed from the soil. The anions most easily removed are nitrate, sulphate, chloride and bicarbonate. The following table (E. J. Russell, " Soil Conditions and Plant Growth ") indicates that the concentration of the drainage water varies from 200–500 p.p.m., equivalent to 0·02–0·05 per cent.

TABLE 17

COMPOSITION OF DRAINAGE WATER : ANALYSIS OF DRAINAGE WATERS FROM CULTIVATED FIELDS (PARTS PER MILLION OF SOLUTION)

	Rothamsted Broad Baulk Field		
	No Manure (Plots 3 & 4)	Dung (Plot 2)	Complete Artificials (Plot 6)
Lime (CaO)	98·1	147·4	143·9
Magnesia (MgO) ...	5·1	4·9	7·9
Potash (K_2O)	1·7	5·4	4·4
Soda (Na_2O)	6·0	13·7	10·7
Iron Oxide (Fe_2O_3) ...	5·7	2·6	2·7
Chloride (Cl)	10·7	20·7	20·7
Sulphuric acid (SO_3) ...	24·7	106·1	73·3
Phosphoric acid (P_2O_5)	0·6	—	1·54
Silica (SiO_2)	10·9	35·7	24·7
Ammoniacal Nitrogen (NH_2)	0·14	0·20	0·24
Nitrate Nitrogen (NO_3)	15·0	62·0	32·9
Organic matter, etc. (CO_2)	67·7	77·3	84·6
Total solids	246·4	476·0	407·6

Soil Water—Three forms of soil water are recognised : HYGROSCOPIC WATER which is adsorbed by a completely dry soil from an atmosphere of water vapour as a result of attractive forces in the surfaces of particles ; CAPILLARY WATER is held by surface tension as a continuous film around the particles and in the capillary spaces whilst GRAVITATIONAL WATER is not held by the soil and drains from it as a gravitational effect.

Soil Moisture Constants—The following terms are in common usage :—

MAXIMUM WATER CAPACITY—The amount of water that a soil can hold when completely waterlogged, i.e., when all available pore space is occupied by water.

FIELD OR MOISTURE HOLDING CAPACITY—The water held in a soil after excess water has drained away under the influence of the force of gravity.

HYGROSCOPIC COEFFICIENT—The percentage of water which a completely dry soil adsorbs from an atmosphere of known relative humidity. It probably varies between about 3 per cent. in light textured soils and 13 per cent. in soils of heavy texture.

WILTING COEFFICIENT (percentage) is the point at which the soil ceases to be able to supply the plant with water at a sufficient rate to maintain turgidity and hence the plant permanently wilts.

MOISTURE EQUIVALENT—The amount of water held by a soil against a force which tends to remove it. The force $(1{,}000 \times g)$ is usually applied by centrifuging.

Probable Relationships of Soil Water Constants—

Hygroscopic coefficient $= 0{\cdot}68 \times$ Wilting Coefficient.
Moisture equivalent $= 1{\cdot}84 \times$ Wilting Coefficient.

Movement of Water in Soils. HYGROSCOPIC WATER—The lower the water content of a soil the more strongly is that water held and, consequently, the greater would be the suction pressure required to remove it. This water, which can be regarded largely as in a non-liquid condition, is adsorbed at the surface of soil and organic matter particles as a thin film not more than 4–5/1,000,000 m.m. (4–5 mu) thick. It is held by a pressure equivalent to c. 20,000 atmospheres or roughly 300,000 lb./sq. in. and its adjustment is confined to evaporation and condensation.

CAPILLARY WATER is that water which is held against the pull of gravity and is present as thin films around the soil particles and in the capillary spaces. The force holding the water in position is due to molecular attraction and movement is as a liquid from thick films to thinner films.

Capillary water is the only permanent form in which soil moisture exists in the liquid state. It contains substances in solution and may therefore be regarded as the soil solution (see page 43).

GRAVITATIONAL WATER is of a transitory nature in the soil draining under the influence of gravity.

Capillary Potential—Capillary potential is the work required to withdraw a unit mass of water from a unit mass of soil. The force exerted (which is in fact a suction pressure) in this withdrawal is less in the case of a soil saturated with water than in one which is just moist. The force, expressed in terms of the height of a column of water in centimetres corresponding to this suction pressure is known as the capillary potential.

pF—To avoid the use of the unwieldy figures necessary to express the force required to remove hygroscopic moisture from the soil the logarithm to the base 10 of the capillary potential is used. This value is usually termed pF.

MOISTURE PERCENTAGE AND pF

	pF
Moisture Equivalent ...	2·7
Field capacity	3·0–3·2
Wilting Coefficient ...	4·2
Hygroscopic Coefficient ...	4·5

The Soil Solution—The movement of water in the soil brings into solution most of the elements present. For all practical purposes the capillary water can be regarded as the soil solution.

Changes in the amount of the solution are dependent on : rainfall, absorptive and retentive capacity of the soil, evaporation and the amount utilised by plants.

The concentration varies with variations in the rate of solution which is influenced by additions of lime, farm manure and fertilizers and by the loss of nutrients to plants and also leaching (drainage) losses.

Plant Nutrition. Composition of the Soil Solution—
The composition and dilute nature of the soil solution is shown in the following table :—

TABLE 18

COMPOSITION OF SOIL SOLUTION DISPLACED FROM CROPPED (7) AND UNCROPPED (11) SOILS

Soil	% Moisture	Date	pH	Parts per million of displaced solution								
				Negative ions				Positive ions				Total Solids
				NO_3	HCO_3	SO_4	PO_4	Ca	Mg	Na	K	
7	12·5	April 30, 1923	7·4	149	83	561	1·1	242	91	42	21	1,190
		Sept. 4, 1923	7·6	58	155	432	0·6	193	47	40	9	935
		April 28, 1924	7·6	252	142	699	0·6	336	76	59	12	1,527
11	12·4	April 30, 1923	8·2	173	160	671	3·3	222	97	87	41	1,454
		Sept. 4, 1923	7·6	16	234	598	1·2	192	64	44	22	1,171
		April 28, 1924	8·1	263	259	785	2·9	276	94	78	35	1,793

Burd and Martin, California (Soil Sci., 1924, 18, 151)
From " Soil Conditions and Plant Growth," E. J. Russell.

The soil solution contains all the nitrate (50–300 p.p.m.) available for the plant, the concentration of the nitrate decreasing with increments of water. It contains small amounts of potash (10–40 p.p.m.) and phosphate (1–2 p.p.m.).

Although the concentrations of K and PO_4 are low they are probably adequate because of the rapidity with which the soil solution is replenished by these nutrients from the soil particle. Although fertile soils tend to have more concentrated soil solutions there is no strict correlation between fertility and concentration.

Soil Reaction and Lime Status—Soils capable of improvement by liming may be infertile by reasons of :—

(*a*) Acidity—shown by lime requirement or pH measurements and corrected by the addition of an alkali.

(*b*) Calcium deficiency—which has a detrimental effect on soil structure and may lead to nutritional unbalance.

The condition of infertility known as " sourness " is characterised by the presence on arable land of certain weeds such as spurrey and mayweed, or in grassland of weeds such as sorrel and bent and old matted turf.

Certain diseases such as " finger and toe " or " club root " in cruciferous crops and the regular failure of certain crops are usually pointers to soil sourness.

Plants show varying degrees of tolerance to soil acidity the approximate order of sensitivity being :—

Sensitive	Intermediate Tolerance	Tolerant
Sugar beet	Peas	Oats
Barley	Beans	Rye
Lucerne	Swedes	Potatoes
Wheat	Turnips	
Mangolds	Kale	
Red clover	Wild white clover	
Cabbage		
Cauliflower		
Carrots		

Nature of Soil Acidity—Soil acidity represents the excess of hydrogen ions (H^+) over hydroxyl ions (OH) in the soil solution. At the same time there may be a reserve of acidity in the form of H^+ ions held by the colloidal complex. The magnitude of the latter is considerable compared with that of the former although both types of acidity tend towards an equilibrium. Soil acidity is expressed in pH units by which pH 7 represents a condition of neutrality.

The pH value is the logarithm of the reciprocal of the hydrogen ion concentration ; the " p " indicates that the value is logarithmic and the " H " that the hydrogen ion is under consideration. In practice the negative sign is omitted.

The degree of acidity of soils can be correlated with the pH scale thus :—

Strongly alkaline	7·5
Slightly alkaline	7·0–7·5
Neutral	7·0
Slightly acid...	7·0–6·0
Moderately acid	6·0–5·5
Moderately to highly acid ...	5·5–4·5
Highly acid	5·0–4·5
Very highly acid	4·5

The correction of sourness involves the neutralisation of the acidity of the soil solution and an increase in the percentage base saturation of the colloidal complex.

Crop failures under conditions of acidity have also been ascribed to soluble aluminium compounds with some certainty in the case of barley but with reserve so far as other crops are concerned.

Calcium deficiency is an important factor in the causation of plant diseases and failures, since certain plants in the presence of sufficient calcium will tolerate low pH.

While calcium appears to be an essential plant food it is used in relatively small amounts by crops as shown in the following table :—

TABLE 19

AMOUNT OF CALCIUM REMOVED FROM SOIL BY AVERAGE CROPS

Crop	Calcium removed from soil CaO lb./acre
Wheat (straw and grain)	10
Barley (straw and grain)	10
Turnips (roots)	30
Mangolds	25
Potatoes	3
Meadow hay	30

The optimum pH for all crops is between 6·5 and 7·0 and is probably close to 6·5, hence, in liming soil, no attempt should be made to produce alkaline conditions. For particular crops the critical pH, i.e., the pH at which failure is likely to occur depends upon seasonal and other conditions.

Lime Requirements of Soils—

TABLE 20

APPROXIMATE WEIGHT OF LIME TO BRING SOIL REACTION TO pH 6·5

CaO required cwt./acre

pH	Light Loam	Medium Loam	Clay
4·0	95	100	115
4·5	70	80	95
5·0	50	60	70
5·5	30	40	50
6·0	15	20	25
6·5	0	0	0

For sands and silts, slightly smaller and slightly larger dressings respectively of lime are required. Lime requirements of soils may also be estimated from the percentage of exchangeable calcium.

TABLE 21

EXCHANGEABLE CALCIUM AND LIME REQUIREMENT

CaO required in cwt./acre

Ex. CaO per cent.	Loam	Clay
0·00	60	70
0·05	50	60
0·10	40	50
0·15	30	40
0·20	20	30
0·25	10	20
0·30	—	10

Calcium (lime) may be lost from soil in the crop or by leaching The approximate magnitude of these losses annually is shown in the following table :—

TABLE 22

Removed by	CaO (lb./acre)
Crop	30
Leaching	300
Total	330

TABLE 23

EFFECT OF LONG-CONTINUED USE OF MANURES ON SOIL REACTION

Acidity increased	Little effect	Acidity reduced
Sulphate of ammonia Protein—blood, hoof meal, etc.	Superphosphate Potassium Salts	Nitrate of soda. Basic slag.
Leguminous green manure crops	Farmyard manure	Calcium cyanamide
	Non-leguminous green manure crops	

(" Soil Conditions and Plant Growth," E. J. Russell.)

Nitrogen—Nitrogen occurs in the soil in inorganic form as ammonia and nitrates, in organic combination in the form of proteins, amino-acids and insoluble complex organic forms.

TABLE 24

AMOUNT OF NITROGEN PRESENT IN SOILS

Soil	Per cent. N
Arable soil ...	... 0·15
Pasture soils ...	... 0·30
Sands	... 0·05
Loams ...	... 0·10–0·30
Organic soils ...	... (app.) 1

TABLE 25
AMOUNT OF NITRATE NITROGEN IN SOILS

Soil	NO_3—N per cent.
Pasture soils	0·001
Arable soils	0·0002—0·002
Horticultural soils ...	0·006

The sources of soil nitrogen are :—

(*a*) Atmospheric nitrogen which is fixed by micro-organisms, e.g., (i) legume bacteria (symbiosis) ; (ii) free-living bacteria.

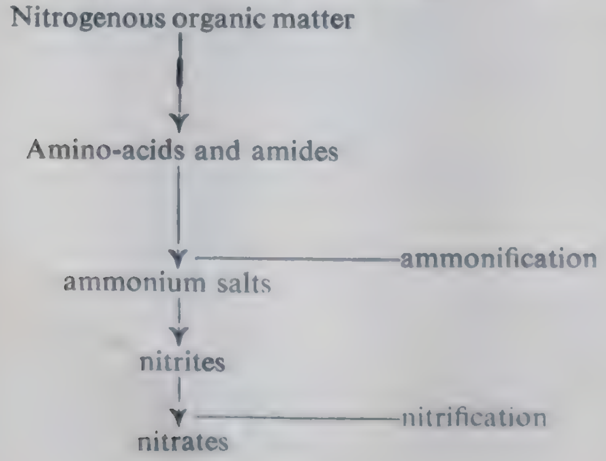
(*b*) Organic matter from unharvested crop residues.

(*c*) Organic (nitrogenous) manures.

(*d*) Inorganic nitrogenous fertilisers.

The Nitrogen Cycle—Plants obtain their nitrogen from such simple compounds as amino-acids and amides, and chiefly from ammonium salts and nitrates. Fresh proteins undergo rapid decomposition in the soil in contrast to the protein of soil organic matter which appears to be highly resistant to micro-biological activity.

The production of nitrates from decaying organic matter is a process of simplification thus :—


Nitrogenous organic matter
Amino-acids and amides
ammonification
ammonium salts
nitrites
nitrification
nitrates

Ammonification is due in part to: (*a*) bacteria; (*b*) fungi; (*c*) chemical changes, and the rate of nitrification depends on the rate of ammonification. Nitrification is the work of specific organisms thus:—

Stage (1) ammonium salts $\xrightarrow{\text{Nitrosomonas}}$ nitrites.

(2) nitrites $\xrightarrow{\text{Nitrobacter}}$ nitrates.

As stage 2 above is more rapid than stage 1 nitrites rarely occur in the free state in soils.

The nitrate content of the soil fluctuates widely over short periods and the production of nitrate depends largely on seasonal influences of which the most important is temperature. It proceeds most rapidly in neutral or very slightly acid soils and in the presence of moisture. Minimum, optimum and maximum temperatures for nitrification are 5° C., 25–35° C., and 55° C. The amount of nitrate nitrogen in the soil depends upon

(*a*) Plant requirements;
(*b*) Leaching losses as soluble salts;
(*c*) Activity of de-nitrifying organisms;
(*d*) Ratio of carbon/nitrogen in soil organic matter.

Utilisation of Nitrogen by Plants—Nitrogen is chiefly absorbed in the nitrate form although certain crops, e.g., potatoes, utilise ammonium salts. Some plants obtain nitrogen by symbiotic relationships with certain fungi (Hymenomycetes), the roots of such plants forming, with the mycelial growth of the fungi, associations known as mycorrhizæ.

Nitrogen Fixation—Soil nitrogen may be increased in the following ways:—

(*a*) Ammonia and nitric acid in rainfall which account for an increment of about 4 lb. of nitrogen per acre per annum in Great Britain.

(*b*) *Free-living bacteria*—

(i) Clostridium pasteurianum, an anærobic organism, which functions in soils over a wide pH range.

(ii) Azotobacter chroococcum—an ærobic organism which appears to be inactive when the soil reaction is more acid than pH 6. These organisms utilise soluble carbohydrates and fix elementary nitrogen in the absence of inorganic nitrogen sources.

(*c*) *Symbiotic relationships of micro-organisms*—Atmospheric nitrogen is brought into organic combination by certain ærobic organisms, Rhizobium spp., which live in symbiosis with particular species of Leguminosæ and possibly other plants. These are the nodule bacteria. In such symbiotic relationships as this the micro-organisms receive their energy supplies from the plant which in turn obtains its nitrogen by autolysis.

TABLE 26
NITROGEN FIXATION BY LEGUMES
(lb. nitrogen per acre [2,500,000 lb.] soil)

Crop	Nitrogen in all crops harvested in 10 years	Nitrogen in soil gain (+) loss (−) over 10 years	Apparent average annual fixation of nitrogen
Red clover	868	532	146
Alsike clover ...	830	595	136
Red and alsike clover	1,054	577	163
Sweet clover ...	1,214	420	163
Sweet clover and vetch	1,155	410	156
Peas and oats ...	493	− 32	46
Field beans... ...	672	−100	57
Vetch and wheat ...	549	97	65
Barley, rye or oats	233	− 52	17

(Extract from—T. L. Lyon and J. A. Bizzell, " A Comparison of Several Legumes with Respect to Nitrogen Accretion," Jour. Amer. Soc. Agron., Vol. 26, p. 653, 1934.)

Loss of Nitrogen from the Soil—(*a*) Nitrogen, as nitrate, is lost from the soil mainly by leaching. Consequently, factors which improve plant growth and thus involve a greater utilisation of water decrease losses of nitrate nitrogen. Such factors also tend to decrease the nitrogen level in the soil due to increased uptake by the crop.

TABLE 27
CHANGES IN NITROGEN CONTENT OF A SOIL KEPT FREE FROM VEGETATION FOR 47 YEARS BUT EXPOSED TO RAIN AND WEATHER.

per cent. N in top 9 in. of soil		lb. N/acre in top 9 in. of soil			N recovered as Nitrate 1870–1917
1870	1917	1870	1917	Loss in 35 years	lb. acre
0·146	0·099	3,500	2,376	1,124	1,247
	0·097		2,328	1,172	1,200

(Miller, 1906, Russell and Richards, 1920—from " Soil Conditions and Plant Growth," E. J. Russell.)

(*b*) Nitrogen is also lost from the soil by the harvesting and removal of crops.

(*c*) Under conditions of imperfect drainage and aeration and in the presence of fresh organic matter nitrogen in a volatile state may be lost from the soil. The loss involves the reduction of nitrate and nitrite by micro-organisms. Ammonium compounds may also be broken down and elementary nitrogen produced.

Effect of Nitrogen in Plants—Nitrogen is concerned with the vegetative development of the plant and to some extent it controls the efficiency of utilisation of phosphorus and potassium. A deficiency results in stunted growth and restricted root development. Visual symptoms of deficiency are yellow or yellowish green foliage ; in extreme cases leaves are shed. Excess of nitrogen is manifest by dark green leaves and soft succulent growth.

By prolonging growth nitrogen, in excess, tends to delay the maturation of crops. In cereals it may cause weakness of the straw by excessive lengthening of the internodes. This generally results in "lodging." Quality may also be impaired and the factor of resistance to disease lowered.

Phosphorus—Phosphorus occurs in soils in apatite—a primary mineral, calcium, iron and aluminium phosphates—secondary sources, and in organic compounds.

The amount present is small, generally within the range 0·02–0·40 per cent., and it is in a more or less insoluble state. Under increasingly alkaline conditions, in the presence of calcium, the following calcium phosphates of decreasing solubility are formed :—

(*a*) oxyapatite	$3\ Ca_3\ (PO_4)_2.CaO$
(*b*) hydroxyapatite	$3\ Ca_3\ (PO_4)_2.Ca\ (OH)_2$
(*c*) carbonate apatite	$3\ Ca_3\ (PO_4)_2.CaCO_3$
(*d*) fluor apatite	$3\ Ca_3\ (PO_4)_2.CaF_2$

Under intermediate conditions of acidity, e.g., pH 4·5–5, the availability of the phosphate is reduced owing to the activity of soluble iron, aluminium and manganese compounds. At about pH 7 the absorption of phosphorus by plants is repressed by the active soil calcium and, in general, solubility of phosphate appears to be greatest at about pH 5·5–6·5.

In the presence of calcium compounds, soluble mono-calcium phosphates, e.g., superphosphate are rapidly converted to the di-calcium salt. This change, which is known as "reversion," takes place shortly after the superphosphate

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reaches the soil. As a result the phosphate is precipitated in a finely divided state ; it is soluble in dilute acid and can be readily utilised by the plant. Should the process of reversion proceed further it results in the formation of one of the insoluble tri-calcium salts described earlier.

Effect on Plants—Phosphorus affects the vigour and quality of plants rather than the yield. By hastening the maturity of crops this element is particularly valuable in short growing seasons. It encourages the development of fibrous roots and thus autumn sown crops are able to make vigorous growth in early spring. Phosphorus also counterbalances the unfavourable effects of excess nitrogen and tends to reduce lodging of cereal crops.

Phosphorus deficiency—Visual symptoms of deficiency are indicated by grey, purple or bronze colorations of the foliage.

Potassium—Potassium occurs in the soil in the form of original minerals such as felspars and mica (see pages 22, 23), as complex mineral silicates of secondary origin and in association with the colloidal complex. The amount present in soils lies between about 0·1 per cent. in sandy soils and 3–4 per cent. in clays.

Effect on plants—Potassium, along with adequate supplies of nitrogen and phosphorus, is requisite to the healthy growth and vigour of crops and is concerned rather with the quality of the crop than with quantity. It improves the natural resistance of plants to disease and insect attack. Potassium is required for chlorophyll formation and is essential for starch formation and the translocation of sugars.

Potassium deficiency—Visible symptoms of deficiency are dry, scorched and curled leaf edges and intravenal chlorosis.

Other Essential Elements—In addition to calcium, nitrogen, phosphorus and potassium certain other elements are requisite to successful crop growth.

SULPHUR is present in soils in association with the proteins of organic matter and in inorganic compounds such as pyrites and gypsum. Amounts varying between 6 and over 60 lb. acre have been reported as reaching the soil in rain water. The changes by which sulphur compounds become available are largely biological.

Hydrogen sulphide and elementary sulphur formed during the decomposition of organic matter are oxidized to sulphites and sulphates, bacteria being largely responsible for the change In the form of sulphates, plants acquire their supplies of sulphur.

SODIUM, which can partially replace potassium as a nutrient for certain plants, e.g., sugar beet and mangolds, is present in all plants. Sodium salts may, in the absence of potash, be used very effectively as fertilizers (sodium nitrate being more effective than calcium nitrate or ammonium sulphate), although their effects appear to be independent of the potash status of the soil.

MAGNESIUM is essential for the formation of chlorophyll of which it is a constituent, and also for the formation of oil. Deficiencies of magnesium are manifest by brown patches in the leaves of apple trees, red and purple colours on the leaves of certain bush fruits and premature defoliation.

IRON is also essential for the formation of chlorophyll but is not a constituent of the chlorophyll molecule. Its absence, or unavailability leads to chlorosis, i.e., yellowing of the leaves, due to the imperfect development of chlorophyll.

This condition which can be remedied by the application of soluble iron salts, is caused by the precipitation of iron as phosphate within the plant and to excessive calcium carbonate in the soil.

BORON is associated with the calcium nutrition of plants and with the effective symbiotic relationships of Rhizobium spp. in leguminous plants. Its absence results in "brown heart" in swedes or "heart rot" in sugar beet which are remedied by the application of about 20 lb./acre of borax.

MANGANESE is an essential constituent of plants although required in small amount. A deficiency results in leaf chlorosis and its absence results in cessation of growth. "Grey speck" disease of oats, which is due to manganese deficiency, is associated with certain soil conditions, namely, high organic matter content and high calcium status. It is curable by the addition of about 45 lb. of manganese sulphate per acre.

COPPER AND ZINC in small amounts are also required for the healthy growth of plants but may be toxic in higher concentrations. "Reclamation disease" in Holland is due to the absence of copper salts. Deficiencies of copper and hence response to soluble copper salts appear to be associated with soils rich in organic matter.

SILICON is present in all plants and appears either to increase the amount of phosphoric acid available in the soil or to facilitate the uptake of phosphoric acid by the plant.

MOLYBDENUM is widely distributed in soils, plants and animals. While deficiencies have been reported in legumes certain calcareous clays derived from the Lower Lias formation have a high molybdenum content and carry herbage of sufficiently high molybdenum content to be toxic to cattle and sheep.

COBALT is present in small amounts in soil and herbage. Deficiency of cobalt, which causes "pining" in sheep, may be corrected by the application of 2 lb./acre cobalt sulphate or chloride to the soil.

Soil Analysis—Soil analysis generally involves the laboratory examination of soil to supplement the field examination. It enables certain " field " characteristics of soils to be precisely defined and provides data on their chemical composition. Its purpose is twofold :—

(*a*) To obtain data by which soils may be classified and their origin and constitution compared.

(*b*) To assess the plant nutrient status in order that deficiencies may be remedied by appropriate manurial treatments.

Methods of analysis may be "absolute," e.g., where the total amount of a particular constituent, or of the amount falling into a definite category, is determined, or " conventional " as in the case of most methods used for advisory purposes. Results obtained by the latter methods are of little significance for purposes other than making recommendations regarding manurial policy.

Because of our incomplete knowledge of soil constitution and the chemical and microbiological changes taking place in it these methods have been evolved for specific purposes, e.g., to ascertain whether soils are in need of lime, phosphorus or potassium.

The former may be attempted in the field by the use of indicators to determine pH, or in the laboratory by :—

(*a*) Electrometric pH determinations ;
(*b*) Determination of Exchangeable calcium ;
(*c*) Hutchinson and McLennan Lime Requirement Method

The wide choice of method suggests that the lime requirement of a soil is, at present, not an absolute figure but a matter of personal opinion. In connection with these so-called lime requirement determinations the need for correlating analytical data with crop response, seasonal data and, of even greater importance, economic conditions, is self evident.

The estimation of phosphorus, potassium and other plant nutrients is based on a presumed distinction between total and available supplies. Various solvents, including 1 per cent. citric acid, 0·5N acetic acid, acetic acid buffered with sodium acetate to pH 4·5, 0·2N nitric acid, 0·005N sulphuric acid and many others, have been proposed to extract the " available " nutrients. This practice is not entirely justifiable since even the most insoluble compound may make some contribution to the nutrition of plants, and each form in which a nutrient exists in the soil will be, to some extent, soluble in a given extractant.

In addition, the amount of available nutrient extracted depends upon the ratio of soil to solvent, the length of time, soil and solvent are in contact while shaking or soaking, and the temperature during this process.

To interpret the results of such analysis there must be adequate correlation with field behaviour.

Owing to the difficulty of interpreting the results of chemical analysis alternative methods have been proposed for the assessment of plant nutrient status of soils :—

(*a*) *Mitscherlich's Pot-culture method* by which the response of crops to increasing applications of a particular nutrient is measured.

(*b*) *Neubauer's Seedling method*—Seedlings grown on the soil are analysed and the percentage of phosphate and potash determined.

(*c*) *Aspergillus niger method*—This method depends upon the growth made by a mould in nutrient solutions from which the nutrient to be assessed has been omitted but to which definite quantities of the soil have been added.

More recently the plant itself has been used for diagnostic purposes by the observation of discolorations of vegetative parts. In conjunction with the assessment of the nutrient status of leaf tissues and the soil, considerable use may be made of this method.

DRAINAGE

Drainage works have two objectives, to prevent or alleviate the flooding of those areas where such flooding would be injurious, and to reduce surface waterlogging or water tables to provide proper conditions for the growth of crops.

Open Channels—The size of a stream or river channel in its natural state is seldom sufficient to contain more than half the maximum winter flow within its banks. Where the adjoining land is used for arable crops, and flooding has to be avoided, the carrying capacity of a channel can be increased by dredging, by straightening, or by the construction of embankments. Summer flood flows are in general much less than winter flood flows and it is consequently possible to contain summer floods by a limited measure of improvement. In some areas flooding does no harm (and may even do good) provided the channels are sufficiently clear to limit the duration of the flooding.

Farm ditches are nearly always artificial, their positions having been fixed in relation to the configuration of the land, nature and changes of subsoil, property boundaries, etc. In low-lying districts the size of the ditches is sometimes governed by the quantity of water which has to be carried but very frequently, especially in upland areas, the principal objects of ditches are to intercept water and to provide proper outfall facilities for under-drainage systems.

Dredging—Hand labour is still used for digging out small ditches, especially those which run along the sides of hedges. The outputs of men engaged on such work vary from 2 to 8 cubic yards per day depending on the nature of the spoil and size of ditch. For normal working a figure of 5 cubic yards per 8-hour day is usual.

Machines are now available capable of excavating in any size of watercourse. For the smallest ditches dragline machines with a bucket capacity of ¼ to ⅓ cubic yard are used. These excavate from 8 to 12 cubic yards per hour, depending on the size of channel.

Shape of Channel—It is usual to make the smallest ditches with a top width equal to the sum of the bed width plus the depth. A good growth of grass serves as a useful bank protection against weathering and scour.

With larger channels it is necessary to slope the batters back to avoid slips. No general rules can be stated because of the great variation in soils. Slopes of anything up to 3 or 4 to 1 are required in some clay soils, while peats may stand almost vertically. The best simple procedure is to check up with existing comparable cases in the area.

It is also necessary to have regard to stock requirements.

The Placing of Spoil—Spoil from watercourses should be spread over as large an area as possible except in those rare cases when the nature of the soil renders this undesirable. Where the amount of excavated material is moderate, it can often be spread direct by the machine and subsequently disced. Larger quantities demand the use of a bull- or angle-dozer.

Care should be taken to keep the spoil slightly back from the edge of the ditch, and gaps should always be left in the spoil tips to enable surface water to drain off. Where hand labour is used a limited amount of spoil can be placed on the hedge side, but it needs to be so placed to avoid the danger of it falling back into the ditch as a result of weathering.

Spoil from ditches often contains large numbers of dormant weed seeds, and steps are often required to deal with the subsequent growth. In certain cases seeding of the spoil is desirable.

Fencing and Cattle Drinking Places—All watercourses liable to be trodden in by stock should be fenced. Opinion varies, but in general a single-strand fence placed 27 in. to 33 in. high will give adequate protection against cattle. Drinking places should always be provided.

Culverts—The minimum satisfactory size of gateway culverts is 9 in. and these should be used only on the smallest ditches.

The following table gives the maximum acreages which can be discharged safely through various sizes of gateway culverts :—

TABLE 28.

Diameter of culvert in inches.	Cross-sectional area in sq. ft.	Maximum Acreage.
9 in.	·42	30
12 in.	·78	60
15 in.	1·23	100
18 in.	1·77	160
21 in.	2·40	225
24 in.	3·14	300

Diameter of culvert in inches.	Cross-sectional area in sq. ft.	Maximum Acreage.
30 in.	4·91	500
36 in.	7·07	800
42 in.	9·62	1,140
48 in.	12·57	1,550

The Benefits of Under-drainage—Drainage results in an increase in the depth and improved aeration of the root zone. The soil warms up quicker, germination is higher and spring cultivation can be carried out earlier. The deeper root zone encourages deeper rooting and stronger plants which are better able to withstand drought.

Types of Under-drainage—The principal methods of under-draining practised to-day consist of tile and mole draining or a combination of the two. Stone, sod and bush draining are seldom used.

Present-day costs demand a careful study of the cause of wetness to enable the simplest possible solution to be devised.

Causes of Bad Drainage—The causes of bad drainage are numerous and a correct diagnosis of the trouble calls for a complete knowledge of the soil and subsoil of the site and surrounding land. Before commencing to design a scheme it is usual to dig out a number of trial holes or to take borings.

In clay and heavy soils general surface waterlogging is usually associated with the inability of the rainfall to penetrate the impermeable subsoil.

Where bad drainage exists in an open permeable soil the cause is usually the level of the subsoil water table.

Wet spots and areas can be caused by the run-off from adjacent areas, by seepage from a pervious layer overlying an impermeable layer or by the upward movement of water under pressure.

Tile Drainage—The best lay-out of a tile drainage system depends on the cause of the wetness and the configuration of the field. Where there is a uniform drainage problem over an area and where the slopes and subsoil condition are also uniform it is usual to lay out parallel lines of tiles. These may either be on a grid or herringbone system. Collecting mains should be provided to break up the length of the minors. In the Fen areas it is fairly common to carry lines of tiles straight across the field from one ditch to another, but in general it is better practice to collect minors into mains.

In undulating fields a random system of draining following the hollows is to be preferred, thereby avoiding excessively deep cuts.

Wherever possible, drains should be laid across rather than up and down slopes.

Where there is seepage from a hillside one or more lines of tiles should be laid just above the seepage line but of sufficient depth to be within the impermeable layer across which the water has been flowing.

The siting and construction of outfalls is of major importance. In general it is better to discharge into a ditch than into a main watercourse. The outfall should be provided with a headwall and apron built into solid ground and the end of the pipe should be protected by a grating or piece of wire netting. Where no headwall is provided, a glazed stoneware or metal pipe should be used with a good projection into the ditch. The ditch should be sufficiently deep to provide a free outfall.

Depth and Spacing of Tile Drains—Current knowledge of the movement of water towards tile drains under varying soil conditions rules out any mathematical connection between tile depth and spacings. In heavy soils where the problem is one of reducing surface waterlogging it is unusual to place tiles deeper than 30 in., the spacing being dependent on rainfall and permeability of the subsoil. In extreme conditions 5 to 7 yard spacings are used, but 11 and 22 yard spacings are common. In light soils where the problem is to avoid excessively high subsoil water tables 3 ft. is a common depth. Under exceptional conditions such as deep rich silts depths of up to 6 ft. are used. It would be dangerous to attempt to lay down fixed rules. The best guide is to determine what spacings and depths have been found to be successful under similar conditions of subsoil in the district in question.

Except where there are definite falls in the land a series of levels should be taken. A useful method in such circumstances is to divide the field up into squares and to take levels at the corners of each square.

When the layout of the scheme has been decided, and particularly where there are limited falls, the lines of tiles should be set out with proper sight rails and as the work proceeds boning rods should be used to ensure the proper grading of the trenches.

The tiles should be laid with their ends butting as closely as possible. As soon as a length is completed a small amount of earth (blinding) should be replaced over the tiles to keep them in position. In some soils it is desirable to cover the tiles with a layer of inverted sods, brushwood, clinker, ballast or wheat straw.

Much work is still done by hand labour but machines are now being used extensively, particularly on the larger schemes.

The machines fall into three types, ploughs, rotary machines and back-acters. Plough-type trenchers, of which there are many examples, give fair results but are rather sensitive to soil type and condition. They work best in stone-free medium clays at times when the clay is fairly moist. Rotary machines dig the trenches quickly but are generally unsuitable in land containing boulders. Moreover, with certain types, sticky clay tends to choke the buckets. The back-acter type of machine is relatively slow in operation but gives useful results even under very hard conditions of digging.

The refilling of tile drainage trenches can be carried out very satisfactorily with the aid of light angle-dozers fitted to wheeled-type tractors.

Length of tile lines per acre for various spacings (excluding mains).

Spacing in yd.	Ft. per acre.	Chains per acre.
5	2,904	44
7	2,073	31·4
11	1,320	20
14	1,040	15·7
22	660	10
44	330	5

TABLE 29

Flow capacity of various sizes of tiles in gallons per hour.

		Slope				
		$\frac{1}{500}$	$\frac{1}{300}$	$\frac{1}{200}$	$\frac{1}{100}$	$\frac{1}{50}$
Tile size	3 in.	600	800	1,000	1,400	2,000
	4 in.	1,400	1,800	2,200	3,300	4,800
	6 in.	4,400	5,900	7,500	11,000	15,000
	9 in.	14,000	18,000	22,000	33,000	46,000
	12 in.	33,000	43,000	51,000	74,000	110,000

TABLE 30

Rates of run-off from various types of soils under different crops.

Mole Drainage—

Grassland ...	1,500 gallons per acre per hour.
Arable	300 gallons per acre per hour.

Tile Drainage—

Heavy land ...	250 gallons per acre per hour.
Light soils ...	100 gallons per acre per hour.

Mole Drainage—This method of drainage is used extensively in heavy clay areas where there is freedom from boulders and lenses of gravel or sand. It is essential that the moles are well into the clay subsoil. For this reason it is advisable to dig a number of trial holes or to take borings with an earth auger over the whole area to be drained. Mole channels are usually drawn at 3 to 5 yard spacings, but in ridge- and furrow-land it is usual to pull one or more moles up each furrow.

The layout of the system is a matter of great importance. On land where the fall is uniformly in one direction the best method is to provide a main drain cutting across all the mole channels near their lower ends, a number of outfalls from the main into the ditch being provided at convenient points. If the length of the field in the direction in which the moles are being drawn is more than 200 yards, further mains should be provided cutting across the moles and slope higher up the field. Where the falls on a field are irregular the mains should be so sited to take advantage of all the naturally low places or valleys.

The best form of main is a well-laid line of tiles laid at such a depth that the top of the tiles is 2 to 3 inches below the floor of the mole channels and covered with a substantial layer of open material such as hedge trimmings, bushes, stones, clinker or clean coarse gravel, through which the moles can " weep " into the main. An alternative but less permanent form of main can be provided by using the mole plough itself to draw several channels along the desired track. It is important that these moled mains should be drawn before the minors and at 3 to 4 inches greater depth. The moled mains need to be connected to the ditch by short lengths of tiled leads.

In fields with little fall a larger number of mains should be provided, thus keeping the length of minors as short as possible. Combined systems of tiled mains and moles are now finding favour as an economical system of under-drainage in place of complete tile drainage systems.

Various forms of equipment are available, the power required being dependent on both the size and the depth of the desired channels. For the heaviest work with 3½ in. channels at a depth of 24 to 30 inches, large track-laying tractors (60 to 70 B.H.P.) are used drawing the mole plough by direct haulage. Ordinary types of wheeled farm tractors can be used only for relatively light work such as 2-inch channels at a depth of about 15 inches. By equipping these tractors with a suitable winch, however, 2- to 3-inch channels can be drawn at a depth of 20 to 24 inches. Certain advantages are claimed for pulling mole drainers uphill only, but it is doubtful whether these claims can be justified for economical working.

Hill Draining—The surface drainage of very large acreages of upland pastures can be improved by means of open grips. The type of layout used is similar to that employed in connection with tile drainage. Wherever possible the grips should be pulled across the slope to intercept the surface flow, the material being deposited on the lower side of the grip. A usual size of drain is 22 inches wide, 14 inches deep, with a 6-inch circular bed. Hill drainage work is now carried out almost exclusively by machine. Several hundred chains can be cut in a day with the aid of a medium horsepower track-laying tractor.

Quality of Drain Tiles—A well-baked drain tile should give a reasonably clear ring when stood on end and tapped with a ight hammer. It should not be possible to see globules of lime exceeding, say, 1/32in. diameter. The pipes should be free from cracks and checks extending into the body of the pipe which might decrease their strength considerably. Tiles should be reasonably straight and of fairly true circular cross-section, the ends being square cut and the insides of the pipe reasonably smooth.

TABLE 31

Weights of tiles (cwt.)

Size	per 1,000
2½ in.	31
3 ,,	40
4 ,,	55
6 ,,	88
9 ,,	170

Costs—Prices are subject to considerable variation at the present time and rates for similar work even in the same soil ype show wide differences from district to district. These variations are due in no small measure to the degree of skill of the workmen. In districts where there is most work the kill is higher and prices tend to be lower.

The prices quoted below are averages and should be used only as a *rough* guide.

In the case of hand labour rates farmers using their own abour or employing men on piecework should show a reduction of from 25 to 40 per cent.

Ditching—

Excavation	By hand per cu. yd.	By machine per cu. yd.
Peat and silts	3/6	1/6 to 2/-
Easy clay	5/-	2/6 to 3/-
Medium clays and mixed soils ...	6/6	3/6 to 4/-
Heavy clays and other soils where the digging is hard due to roots, stones, boulders, etc.	7/6 to 10/-	5/- to 8/-

An average figure of excavation for a hedgeside ditch is 7 cu. yd. per chain. Such a ditch would cost about 45s. per chain with moderate conditions of digging.

Hedging Preparatory to Ditching—With hedgeside ditches an allowance must be made for setting up the hedge preparatory to excavation. Such work must obviously vary considerably, the usual range of costs being 5s. to 20s. per chain, but this might well be exceeded, especially where trees need to be trimmed back to enable a machine to work.

Spreading—From 6d. per cu. yd. for loamy soils to 2s. for heavy soils.

Culverts—The following prices are for culverts 18 ft. long with simple headwalls :—

9 in.	£9
12 in.	£12
18 in.	£15
24 in.	£20

Fencing—A single-strand fence with posts at 5 yard centres costs approximately £1 per chain. Additional strands of wire can be provided at 3s. per chain.

Under-drainage—

Trench excavation, tile-laying and backfilling

	Costs per chain	
	Hand	Machine
Easy digging, 3 ft. deep in silts, etc. ...	20/-	17/6
Normal digging, 2 ft. 6 in. deep in medium clays	50/-	35/-
Hard digging, 2 ft. 6 in. deep in heavy clays	75/-	50/-
Very difficult digging 2 ft. 6 in. deep ...	90/-	70/-

(Note.—These costs are specially liable to variation fron district to district.)

Porous Filling—

Bushing	5s. per chain (assuming hedg trimmings available free).
Clinkering or ballasting	15s. to 20s. per chain, includin material.

Mole Draining—

Eastern Counties ...	40s. to 50s. per acre at 3 yd spacings.
Elsewhere	Add up to 50 per cent.

Tiles— Prices per 1,000 ex works.

	Average	Min.	Max.
2½ in.	142/-	120/-	162/-
3 in.	161/-	146/-	181/-
4 in.	230/-	208/-	269/-
6 in.	418/-	343/-	494/-
9 in.	915/-	653/-	1,200/-

MANURES AND FERTILISERS

A *manure* may be regarded as a relatively bulky substance whose main contribution to the soil is the supply of organic matter. A *fertiliser* is a more concentrated substance primarily supplying at least one, if not two or more, of the essential plant-foods. Thus, farmyard manure, green manures, rotted straw or peat, are all manures, but sulphate of ammonia, superphosphate, or muriate of potash are fertilisers. This distinction is not always made, the word " manure " still being widely used, e.g., " chemical manures," " patent manures," etc. ; however, this loose terminology frequently leads to confusion, for in modern fertility practice manures and fertilisers have separate functions even though there may be some degree of overlapping. Soil fertility rests upon three complementary types of soil addition or amendment : (1) organic matter to replenish and maintain the humus status of the soil ; (2) plant-foods to correct deficiencies and balance crop removals and current losses ; and (3) lime or limestone to check soil acidity and keep the pH of the soil within a favourable range for good cropping. It is true that most manures also provide small amounts of simple plant-foods whilst some fertilisers contain a little organic matter. However, the plant-food content of manures is significant only when very large dressings per acre are given, and even with organic fertilisers such as bone meal or hoof and horn meal the humus-forming organic matter in quite high dressings is small in amount and effect.

In the past too much attention has been paid to the plant-food content of manures and too little to their humus-making potentialities. Detailed chemical analyses for various animal manures are not as useful as many farmers believed. For one reason, manures are very variable in their contents of plant-foods ; in practice, samples on farms display considerable deviations from any figures that are considered to be normal or average. For another reason, a variable part of the nitrogen and phosphoric acid present is only slowly available to crops ; thus, actual figures determined in the laboratory may be inflated indications of the value of the manure as a supplier of plant-foods. Long-term tests at Rothamsted have shown half the nitrogen content of farmyard manure to be so slowly effective that it may be lost in soil wastage processes rather than taken up by spring and summer crops.

On the other hand, the organic matter (and possibly certai organic trace substances) in bulky manures are of great valu to soils. Organic matter is essential for the maintenance o a good physical condition of the soil, e.g., particle size an moisture-holding capacity. It is essential as a food for so bacteria which " handle " important stages in the nitroge cycle. Recent American research has suggested that by-product from organic matter decomposition in soils can minimise th serious loss of available phosphates by fixation, i.e., combinatio with iron and aluminium in soils so that very insoluble an unavailable phosphates are formed. The actual amounts c organic matter in manures again vary considerably, largel because moisture contents of farm manures also var Generally, a farm manure contains as much as 75 per cent. c its weight of water ; thus, a 5 ton per acre dressing will in fa represent rather less than 1 ton of added organic matter.

The following data for the average compositions of manur should be interpreted in the light of the foregoing comments :-

Table 32—Percentage Composition of Manures

	Nitrogen	Phosphoric Acid (P_2O_5)	Potash (K_2O)	Moisture	Organi Matter
	per cent.	per cent.	per cent.	per cent.	per cen (very approx
Manure					
Cow	0·3–0·4	0·15–0·2	0·4–0·45	75–80	20
Bullock	0·5–0·6	0·2–0·25	0·6–0·7	75–80	20
Pig...	0·4–0·5	0·2·0·25	0·5–0·6	70–75	25
Sheep	0·7–0·85	0·2–0·25	0·6–0·7	65–70	30
Horse	0·5–0·6	0–2·0·3	0·5–0·6	70–75	25
Liquid manure ...	0·1–0·2	0·1–0·07	0·4–0·5	98	less tha
Night soil ...	0·6–1·0	0·2–0·5	0·2–0·25	80–95	5
Dried sewage sludges (very variable) ...	0·5–2·0	0·5–3·0	traces to 0·5	8–40	10–40
Poultry Manures (fresh)					
Hens	1·3–1·7	1·5	0·7–1·0	50–60	25
Ducks	0·75–1·0	1·2–1·5	0·5–0·7	50–60	25
Geese	0·5–0·6	0·5–0·75	0·75–1·0	70–75	15
Composts					
Crop wastes and dung (Indore) (dry basis data)	0·7–1·5	0·9–2·5	0·5–1·5	—	30–4
Town refuse compost	0·8	0·5	0·3	—	—
Straw compost ...	0·4–0·5	0·25	0·2–0·4	70–75	20
Fresh seaweed ...	0·2–0·3	very low	1·0–1·5	80	15

Farmyard Manure.—Older figures have exaggerated the amount of farmyard manure which can be produced by herds. A standard Ministry of Agriculture estimate, based upon a number of investigations, is that 50 head of mixed cattle produce from 150 to 180 tons of manure per annum.

A useful table for estimating rates of dressing with farmyard manure based upon 2-ton loads of manure is given below and indicates the number of heaps into which the loads must be divided to give the required rate of application :—

TABLE 33—Rates of Dressing with Farmyard Manure.

Distance of heaps apart —yards	5 tons per acre	10 tons per acre	15 tons per acre	20 tons per acre
5 × 5	75	37½	25	19
6 × 6	53	26½	18	13
7 × 7	39	19½	13	10
8 × 8	32	16	11	8

In providing litter materials for cattle in sheds or yards, the capacity of litter to absorb moisture is of great practical significance.

TABLE 34.
ABSORPTIVE POWER OF DIFFERENT LITTERS.
(Weight of Water to 1 of litter.)

Sand	0·25	Oat straw	2·28
Vegetable mould ...	0·50	Barley straw	2·85
Fir needles	2·00	Moss	2·75
Dead leaves	2·00	Sawdust of fir ...	4·20
Ferns	2·12	Tan bark	5·00
Wheat straw ...	2·20	Peat-moss litter ...	6:00

Many losses occur in the production of farm manure. Some loss is inevitable, but the extent of loss can be greatly reduced by sound practice.

Nitrogen is readily lost. Much of the active (or quickly available) nitrogen excreted by an animal is found in the urine, where it is mainly in the form of urea. Urea, however, is readily converted by bacteria into ammonium carbonate, an extremely volatile compound ; the customary ammoniacal smell of a cattleshed or cattleyard is mainly due to the evaporation of ammonia from ammonium carbonate.

$$\underset{\text{urea}}{CO(NH_2)_2} + \underset{\text{water}}{2H_2O} \rightarrow \underset{\text{ammonium carbonate}}{(NH_4)_2CO_3} \rightarrow \underset{\text{carbon dioxide}}{CO_2} + \underset{\text{water}}{H_2O} + \underset{\text{ammonia}}{2NH_3}$$

This loss takes place very rapidly and steadily. It can be reduced if the bed of litter and manure is kept in a compact condition, thus minimising the contact with air and the tendency for the ammonia to volatilise. It is also important to use a litter material with high absorptive capacity. The treading of the cattle is the most practical method by which a compact litter-bed can be maintained. An open or earth floor beneath the litter will offset this method of economy for liquid seepage will pass into the earth ; cemented or concreted floors beneath litter beds are desirable.

Some authorities advocate the frequent application of fresh manure to farm fields. By this method, the losses of handling and storage are certainly minimised, but to-day the time and labour involved in such a policy probably offsets the value of this economy. The traditional manure heap and the annual dressings to certain fields on the farm is still the most economical system *provided* the heap is made and stored so that losses are kept to a minimum. The principal " rule " is to keep the heap compact, excluding the entry of air as much as possible ; too much air causes rapid bacterial action and over-heating, the result of which is loss both of more nitrogen and some organic matter. There must always be a substantial loss of organic matter for the " fermentation " processes convert a good deal of this into carbon dioxide and hydrocarbon gases. The amount of carbon-containing matter left in the final manure is considerably governed by the amount of nitrogen present. The processes of decomposition can be said to aim at a final carbon/nitrogen ratio of 10 : 1, and most fresh manure heaps start with much higher carbon/nitrogen ratios. It follows from this the probability of organic matter loss is much greater if the nitrogen in the heap has also suffered severe losses. Conservation of nitrogen in manure handling means conservation of organic matter. As the most important function of manure is to supply organic matter to soils this aspect of farm manure production should never be forgotten.

Heavy rain causes severe losses of all soluble plant-foods in the heap. On the other hand, moisture is needed in the bacterial processes of the heap : also, moisture helps to retain gaseous ammonia and to cool the heap. It is desirable to leave the heap exposed to summer raintall but to have it protected from rains in autumn, winter, and at least the early spring. Seasonally varied cover for the heap may not be easily practicable on most farms. Permanent cover should therefore be provided and in summer months the heap can be kept moist with occasional hose-waterings.

In many cattle-houses it is possible to run the urine int tanks. This is a desirable feature in any building where stoc are kept for periods. The urine should be pumped from collection tanks on to the heap at frequent intervals. Its nitrogen content improves the conservation-economy of the heap, and it is less likely to be lost in the heap than in the tank.

The heap should not be built on a wind-exposed site as this would obviously increase the risk of air entrance and ammonia losses by volatilisation.

Sheep and horse dungs ferment more actively and produce higher temperatures in doing so ; a principal reason for this is that their dung is more difficult to compact and it therefore has greater exposure to air.

* * *

A cubic yard of farm manure in the heap weighs about 12 to 16 cwt.

Tanks for collecting urine should have a minimum capacity of 4 cubic feet per head of stock. This allows for 7-10 days' output of urine plus about 30 per cent. of additional liquid from rain, washings, etc.

It is often stated that manure should be applied to the soil many weeks in advance of sowing. This is questionable. The active proportion of plant-foods is likely to be lost before the seeds have germinated ; and the slowly available proportion will not be much more active by that time. Inasmuch as manure is locked upon as a source of plant-foods, it should be applied shortly before sowing or planting. As for its function as a humus-provider, this is always a long-term benefit and time of application to a soil would not seem to be significant.

Small heaps of manure should never be left standing on the field for severe losses from excessive contact with air will occur. If application is made by first placing small heaps over the field, the manure should be worked into the soil without delay.

Farm manure is invariably low in phosphate content ; cow manure is particularly low in this plant-food as so much phosphate in the cow's food is passed into the milk. Even a high rate of dressing with manure must not be expected to maintain phosphate sufficiency for a good cropping level.

In choosing arable fields for manure treatment, it is useful to remember that poor soils are more likely to profit from it, especially light soils. Wheat responds notably well to manure dressings ; the ideal dressing for potatoes and many root crops is manure plus a complete fertiliser. The policy of manuring permanent grassland for hay is probably wasteful ; permanent grassland is generally well supplied with organic matter so that the main contribution from the farm manure—humus-forming material—is often no more than an addition to sufficiency. Where the " balance " of the farm permits, manure should be given mainly to the arable fields, and those arable fields which have the lowest fertility should have priority of treatment.

Composts from Straw, etc.—Useful organic manure can be made by composting straw. It is necessary to supply a suitabl nitrogenous fertiliser, some ground lime carbonate, and plent of water. The bacteria which operate many of the decomposition processes require nitrogen, and will not function activel under acid conditions or in the absence of moisture. Composting heaps should be as large as possible to avoid heat losse by excessive surface exposure ; the larger the heap, the smalle in proportion is the outside surface. Some authorities argu that as much benefit is derived if the straw is ploughed in an the same amount of added nitrogen given to the soil ; mor than one comparative test has supported this argument. A dressing of sulphate of ammonia or nitro-chalk should be give if straw is directly ploughed back into the soil ; if this is no done, the decomposing bacteria " lock up " available nitroge in the soil, and the subsequent crop may suffer from nitroge deficiency.

Fertilisers—The overwhelming proportion of fertilisers use in modern farming is composed of *mineral* fertilisers. To-da the tonnage of *organic* (i.e., of organic origin) fertilisers used relatively small except in intensive market garden cropping an glasshouse cultivation. It is convenient, therefore, to trea mineral and organic fertilisers separately.

Fertilisers may consist of one mineral substance whic provides one (and occasionally two) of the major nutrient nitrogen, phosphorus, and potassium : such fertilisers a known as " straights." " Straights " may be mixed at factory or on the farm to give a compound fertiliser, i.e., balanced mixture which usually provides the three mai nutrients in suitable ratios for crop or soil needs.

The plant-food content of fertilisers is clearly shown in the statutory declarations of analysis. Analysis must be stated terms of :—

(*a*) nitrogen percentage,
(*b*) water-soluble phosphoric acid percentage : often state as phos. acid or P_2O_5, which are recognised abbreviation
(*c*) insoluble phosphoric acid,
(*d*) potash percentage, often stated as K_2O percentage.

These chemical substances do not exist in fertilisers in the forms ; for example, nitrogen is a gas, phosphoric acid is liquid, and " potash," or potassium oxide, is very caustic a would be a most unsuitable material for handling. All the substances exist in fertilisers in combination with oth elements and in suitably stable forms, both chemically a physically. In order to have a common "yard-stick" for evaluating all fertilisers, analyses must be stated in terms of the *chemically equivalent* percentages of nitrogen, phosphoric acid, and potash present. Many years ago, the equivalent percentages of ammonia and calcium phosphate were stated instead of nitrogen and phosphoric acid respectively.

Nitrogenous Fertilisers—SULPHATE OF AMMONIA—20·6 per cent. nitrogen. May be made as by-product of gas or coke manufacture or by synthetic fixation of the nitrogen in the air, the latter process providing about three-quarters of the production. It tends to set hard in bags during long storage, but recent progress in modifying the crystal shape has eased this problem, especially for the synthetic product. Readily water-soluble, sulphate of ammonia is a quick-acting fertiliser. Its frequent use tends to increase the development of soil acidity; the crop's uptake of the alkaline "ammonia part" of this salt leaves behind the acidic "sulphate part," which attaches itself to free lime or other bases in the soil. This effect is easily compensated by watching the lime status of the soil and dressing with lime when necessary.

NITRO-CHALK—15·5 per cent. nitrogen. A widely used proprietary fertiliser, based upon synthetically manufactured ammonium nitrate. Ammonium nitrate and calcium carbonate are mixed and the resultant product is in the form of dry granules. The nitrogen content is partly in the ammonia form and partly in the nitrate form; consequently it is a very quickly-acting fertiliser. It is essential to keep this fertiliser dry in storage or transit. Moisture not only leads to the break-down of the granular form but to chemical reaction between the ammonium nitrate and calcium carbonate whereby gaseous ammonia is liberated and lost. Wet nitro-chalk is almost impossible to handle. Packed in special moisture-proof bags, it is unwise to have half-used bags left at the end of dressings unless very dry storage can be given; even then, the material should be used at the earliest opportunity.

NITRATE OF SODA—16·0 per cent. nitrogen. Produced from the natural nitrate deposits of Chile, though to-day some nitrate of soda is derived from synthetic fixation of atmospheric nitrogen. All the nitrogen being present in the nitrate form, the most quickly plant-assimilable form, this fertiliser is very rapid in action. It has the reputation of making heavy soils stickier if regularly used owing to the formation of sodium clays in the place of calcium clays; but this effect would probably not be so widely experienced to-day when liming is more generally carried out as this offsets the tendency of sodium residues in nitrate of soda to form sodium clays. As a chemical substance, nitrate of soda absorbs water readily and this property creates handling problems in wet weather applications or during storage under damp conditions. In the past the sodium content of this fertiliser has been ignored. Certain crops, particularly sugar-beet and mangolds however, derive considerable benefit from sodium, and dressings of agricultural salt are then given, but if nitrate of soda is used as the source of nitrogen, the effect of this salt dressing is obtained from the sodium in the nitrate of soda. Chilean nitrate of soda also contains small amounts of trace elements which may often be useful.

CALCIUM CYANAMIDE—About 20 per cent. nitrogen. An early " synthetic " fertiliser ; made by fusing lime and coke in an electric furnace and passing atmospheric nitrogen over the fused mixture. It must be applied to soils some weeks before sowing as it has toxic effects upon plant-life which disappear upon exposure ; for this reason it has some merit as a weedkiller. Little cyanamide has been available in Britain since 1939.

Other Nitrogenous Fertilisers—In the United States, there has been considerable development in recent years of Urea (46 per cent. nitrogen), *liquid ammonia* and solutions of ammonia, and combined solutions of ammonia and urea. The nitrogen contents of these are high. So far similar developments have not taken place here.

AMMONIUM PHOSPHATE—A powerful fertiliser produced by combining synthetic ammonia with phosphoric acid ; it generally contains 11 per cent. nitrogen and 48 per cent. phos. acid. It is mainly used, however, for manufacturing high analysis or concentrated compound fertilisers and only a relatively small proportion of British production is used as a " straight " fertiliser.

POTASH NITRATE (usually about 15 per cent. each of nitrogen and potash) is produced from the Chilean deposits. It is used for market garden crops, mainly as a summer top-dressing.

Though the last two fertilisers are " straights," it will be noted that they supply two of the major plant-foods. They are not, however, compound fertilisers as the double possession of nutrients is inherent in their chemical nature and has not been secured by deliberately mixing two fertiliser materials ; also, the ratio of the nutrients is pre-determined by their chemical nature and it cannot be varied over a wide range as is the case in compounding mixtures.

Phosphatic Fertilisers.—MINERAL ROCK PHOSPHATE—There are numerous deposits of calcium phosphate in the world though unfortunately no suitably rich deposits have been discovered in Britain ; for Europe the main deposits lie in North Africa.

Rock phosphate is believed to have a long-distant animal origin, mainly marine ; the mineral form is not that of simple tri-calcium phosphate. Geological infiltration of fluorine has taken place in its long history, and the resultant chemical form is complex, one serious effect of the fluorine being to make the phosphate content much less available to plants. To convert the raw rock into active phosphatic fertilisers, acid or fusion processes are needed, see Superphosphate, etc. Some grades of rock phosphate are fairly effective slow-acting phosphatic fertilisers when very finely ground, especially in application to acid soils. Ground rock phosphate, containing about 26 per cent. insol. phos. acid, has been considerably used for grassland in Britain in recent years. Some of this usage may be attributed to shortage of basic slag.

SUPERPHOSPHATE—Usually 18·0–18·5 per cent. sol. phos. acid. In 1839-40 Liebig suggested that bone phosphate might be made more quickly available to plants if bones were treated with acid. The chemical idea behind this was that insoluble tri-calcium phosphate would be converted into the more soluble mono- and di-calcium phosphates. Lawes put this theoretical suggestion into practice and in 1840-41 produced the first commercial superphosphate from bones ; he quickly turned to mineral phosphates, of which there were low-grade deposits in England, owing to the shortage of raw bone. Thus superphosphate soon became a mineral-based fertiliser. Later, much higher-grade rock phosphate deposits were discovered abroad and these were imported. To-day all our superphosphate is based upon imported rock phosphate. The acid used is sulphuric acid. In the acid treatment a substantial proportion of the fluorine in the original mineral is removed and this may account for the greater availablity of the phosphatic content of superphosphate quite as much as does the water-solubility which it attains. Whether water-solubility is the best criterion for phosphate availability is a matter of controversy; it is a fact that reversion to insoluble phosphates takes place soon after water-soluble phosphate is mixed with soil, and these "reverted" phosphates must still be slowly dissolved by the soil solution if they are to become available to plants.

Two common illusions about superphosphate should be disposed of. The now little-used name "superphosphate of lime" led many users to suppose that it also supplied lime to soils. There is no free or uncombined lime in superphosphate ; though it has a useful content of calcium, which is an essential plant-food. The knowledge that strong acid is used in making superphosphates has led others to assume it is an acid fertiliser. This is also incorrect ; the use of superphosphate does not increase soil acidity.

The most widely used phosphatic fertiliser, superphosphate is an effective base-dressing for all crops ; as one of the principal functions of phosphate is to stimulate germination and early root development, it is preferable to apply base dressings at or just before sowing-time rather than to apply top-dressings during growth. Similarly early spring application to grassland is preferable so that the maximum help is given to new spring-growth.

The physical condition of superphosphate is fairly good. It does not absorb moisture excessively and remains friable under reasonable storage conditions.

Basic Slag—A by-product of the steel industry, basic slag has an excellent reputation as a grassland fertiliser, especially where clover is established. In the steel process it is essential to remove the phosphorus in iron ore, and the slag which is formed on the surface of the molten metal contains most of the phosphate together with alkaline materials used in the blast furnace " mix." The slag therefore contains both phosphate and liming material. It is not an effective fertiliser unless finely ground. Applications are slower in immediate effect than those of superphosphate but the benefits are fairly long-lasting. The analysis of basic slag varies considerably from 9–18 per cent. insoluble phos. acid. Unfortunately, many grades of slag are too low in phosphate content to be economically worth grinding, especially with the modern tendency of the steel industry to select iron ores with low phosphorus contents. Basic slag should be carefully stored. Long storage in damp conditions leads to setting and slag which has reached this condition is practically impossible to handle. For acid soils basic slag is probably superior to superphosphate even for arable crops ; in British arable farming, however, it has been mainly confined to heavy soils though in German farming it has a long record of success in light soils as well. The non-expanding supply of basic slag has not kept pace with the expansion in fertiliser demand since 1940 and basic slag is in limited supply at almost all times of the year.

Triple Superphosphate—By using phosphoric acid instead of sulphuric acid in the superphosphate process, a much more concentrated phosphatic fertiliser can be made from mineral phosphate having a sol. phos. acid content of 40–48 per cent The process is more costly and *pro rata* triple superphosphate is likely to cost more per ton ; however, the greater cost of the same amount of phosphate in a dressing may be offse by the saving in transport, labour, etc. Also, in severely deficient soils, larger phosphate dressings can be given without exceeding the maximum application rates of drills. Triple superphosphate was imported under Lend-Lease arrangement during the war and was much favoured by farmers. It is possible that this was due to its excellent granular condition as well as its higher phosphatic content. Production in this country has recently commenced.

SILICO-PHOSPHATE—Rock phosphate can also be "activated" by fusing with silica, e.g., sand, and there have been a number of attempts to develop this type of phosphatic fertiliser—in Holland and Germany, in recent years in East Africa, and for an experimental period in this country during 1939-45. "Silico-phosphate" was the name given to the wartime product of Ministry of Supply experiments in Kent. Field tests showed this fertiliser to be comparable with superphosphate in effectiveness. It is an alkaline fertiliser and therefore likely to be especially useful under acid conditions. Further production has not yet taken place but fusion methods of treating phosphate rock are almost certain to be commercially developed some time in the future. The most cogent reason is the increasing scarcity and price of sulphuric acid so heavily used in the superphosphate process.

Potash Fertilisers—MURIATE OF POTASH—40-60 per cent. K_2O. Most of our potash supplies are in the form of muriate, i.e., chloride. This is mined in Germany and France, and has also been recovered from the Dead Sea, though this modern source was severely reduced by damage in the Arab-Israel war. In the last ten years potash deposits have been found in this country in Yorkshire and urgent development work is in progress to establish this internal source; it remains to be seen whether British potash can ultimately be economically competitive with the potash from established mines in Europe. To produce high-grade muriate of potash the crude potassic salts are purified by crystallisation processes.

Older-known and lower grade products such as kainit and potash salts (12-30 per cent. K_2O) are seldom handled to-day, labour and transport costs being saved by importing and issuing the higher-grade muriate. In 1949-50 most of the muriate used here was of the 55-60 per cent. grade but for a year or two before considerable tonnages of 40 per cent. material had to be used owing to scarcity of the better grades.

The high chloride content of muriate has often been feared but it is now clear that in normal cropping chloride residues are not held by the soil to any dangerous extent; under glass, however, and for some horticultural crops, sulphate of potash is preferable. The main trouble with muriate of potash is the tendency to absorb enough moisture to set into hard blocks in the bags. Hence, many farmers prefer to apply potash to their crops in the form of high-potash containing compounds.

SULPHATE OF POTASH—48·5–50 per cent. potash. This is to-day generally manufactured from muriate by chemical processing ; natural supplies of sulphate have been declining steadily. A better fertiliser for physical condition than muriate, but mainly used in intensive cultivation work where chloride accumulation may possibly have adverse effects upon quality and appearance of crop (see page 75). The higher price per ton, coupled with a lower potash content, restricts the use of this fertiliser in farming.

Also, see POTASH NITRATE under Nitrogenous Fertilisers.

NITRATE OF POTASH, or saltpetre, is not identical ; it is a little lower in nitrogen content and much higher in potash content, about 40 per cent., and is produced in India by leaching soil extracts and drying the leachings in the sun, thus producing crude saltpetre. Production and supplies to-day are much smaller than they were 20 or 30 years ago ; indeed, this once well-known horticultural fertiliser is only rarely available in Britain.

WOOD ASHES, etc.—Ashes from the combustion of organic matter are useful as minor sources of potash, the potash remaining in the ash while the more volatile and bulky organic matter has been lost in the gases of combustion. Wood ashes may contain from 2–5 per cent. of potash in the form of potassium carbonate ; however, most of this is lost by " washing out " if wood ashes, etc., are left exposed to rain. Young wood, e.g., twigs, shoots, etc., contain higher amounts of potash since potassium tends to accumulate in fast-growing points of plants. At one time sea-weed ashes or kelp were used considerably, sea-weeds being richer in potash content than most land plants ; little use is made of sea-weed ashes to-day though the direct addition of sea-weeds to soils as organic matter is practised in certain areas, e.g., Cornwall, Channel Isles, etc.

Organic Fertilisers—This term implies that the fertilisers are of organic origin. Synthetic urea, for example, is an organic chemical in the correct use of this term, but it would be incorrect to call it an organic fertiliser. Materials of animal or vegetable origin such as dried blood or castor meal fall into this empirical class but not the manufactured organic chemicals.

The principal merit in most of these substances is the fact that the plant-foods are in complex chemical forms as a result of their natural synthesis in the animal or plant. These complex forms are only slowly broken down in the soil by bacteria and therefore a steady and lasting nutrient supply is provided ; also, they are generally insoluble in water and there is little risk of loss to rain during the period of action. For the same reason, huge dressings can be given without any risk of producing so concentrated a soil solution that plants suffer damage. These are practical reasons for the great favour in which organic fertilisers are held by intensive growers, and they are to be preferred to mystic explanations which assume, without tangible evidence, that organic matter has some exceptional virtue through having once been part of living structural substances.

The principal organic fertilisers used to-day are :—

Nitrogenous Organic Fertilisers—HOOF AND HORN MEAL, HOOF MEAL, AND HORN MEAL—12–14 per cent. nitrogen. Fine or coarse grades. Should be base-dressed a few weeks before sowing or planting out ; finer ground meals release nitrogen more quickly than coarser grades. During warm soil conditions the nitrogen release is fairly rapid. Much used by intensive growers of green vegetable crops.

DRIED BLOOD—12–13 per cent. nitrogen. Quality depends upon method of drying which should not have been so fierce that a crude or almost charred product results. Exceptionally rapid in action as it forms colloidal (or mock) solutions, thus giving intimate and large-surface contact with soil and soil bacteria. Mainly used in glasshouse cultivation and specialist gardening.

SHODDY—Nitrogen analyses very variable ; figures from 3–12 per cent. are known. Quality depends upon proportion of pure wool wastes, sweepings, etc., in the shoddy. Although shoddy analyses do not legally have to be declared, it is wise to buy only on analysis. The release of nitrogen to crops is fairly slow, but shoddy has a great reputation for improving the physical condition of soils. Since 1939 the total amount of shoddy available from the wool and clothing industry has fallen sharply.

LEATHER WASTES—Leather wastes contain up to 5 per cent. of nitrogen but unless processed by acid or steam treatment into genuine leather fertiliser meals the nitrogen content is so slowly available that it has little value. Treated leather wastes have never been popular in British practice but they are considerably used in America.

Phosphatic Organic Fertilisers—BONE MEAL—3·7–4·5 per cent. nitrogen, 20–24 per cent. insol. phos. acid. Variable benefits obtained from bones used as manures from 1750–1820 led to the idea that bone must first be ground to powder or small grist. This was stimulated by the successful use of knife-handle grinding wastes in the early days of the Sheffield knife industry. Though the nitrogen content of bone meal is small, it is fairly active. The phosphate content is much slower in action than, say, that of superphosphate. Large tonnages used to be imported from India but since the war this supply has diminished ; home produced supplies obviously depend upon the numbers of home-killed cattle and upon the tonnage of meat imported which has not been boned before shipping. Bone meal for fertiliser use must compete with bone meal for feeding-stuff use.

Steamed Bone Meal and Flour—Steam treatment of bones removes fats, greases, etc., and glue-making material : a good deal of the nitrogen content of bones is removed with these. The residual material, therefore, is lower in nitrogen content and higher in phosphate content. According to the degree of steam treatment, the bone softens and—after powerful steaming—can be very finely ground to a powder. This is *steamed bone flour*. The residual product of gentler steam treatment is *steamed bone meal*.

Approximate analyses :—

Steamed bone meal } 0·5–0·8 per cent. nitrogen,
Steamed bone flour } 26–29 per cent. insol. phos. acid.

Judged as phosphatic fertilisers, these should be regarded as superior to bone meal for speed of action. There is usually a price advantage over ordinary bone meal.

Meat and Bone Meal—Produced from mixed flesh and bone wastes at slaughter-houses, meat processing works, etc. Analysis varies according to proportions of " meat " waste, mainly nitrogenous, and bone waste, mainly phosphatic. Heat treatment gives a final powdery product of mixed particle size. Formerly this type of fertiliser was often called *meat guano* : in America it is always called *tankage*, and some imported consignments from other countries adopt the American name.

Usual range of analysis—3–7 per cent. nitrogen,
9–16 per cent. insol. phos. acid.

Probably quicker in nitrogenous action than phosphatic action, meat and bone meal is a popular fertiliser for intensive vegetable and soft fruit cultivation.

Fish Meal, Fish Manure—Similar product to meat and bone meal but derived from mixed fish wastes at fisheries, fish canning works, etc. Generally more rapidly active than meat and bone meal. Much used in tomato and soft fruit cultivation and as an ingredient of compound fertilisers for high-class market crops. Formerly often called *fish guano*.

Usual range of analysis—7-14 per cent. nitrogen.
9–16 per cent. insol. phos. acid

Seven per cent. nitrogen and 12 per cent. insol. phos. acid is a frequent analysis in current fish meals.

Other Organic Fertilisers—There are numerous other organic fertilisers, e.g., skin and bone meal, castor meal, cocoa meal, dried bird guanos (which are not imported into this country to-day on anything like their previous scale), etc. It is necessary to judge these products upon their analyses, comparing them for price with the main organic fertilisers.

Potash in Organic Fertilisers—Except in the true guanos, i.e., genuine bird excrements, the potash content is insignificant in organic fertilisers. However, potassium remains "mineral" in nature even in living organic matter—it does not significantly take part in the synthesis of complex organic substances though its presence influences the processes of natural synthesis. There is no reason, therefore, to pay more than mineral fertiliser prices for potassium even if "organic potassium" claims are made.

Compound Fertilisers—Mixed or compound fertilisers are made from the various "straight" fertilisers already discussed, though certain of them cannot be mixed together without undesirable reactions. The object of compounding is to produce a fertiliser with a specific ratio of the three main plant-foods (*a*) suited to a crop and soil, and (*b*) so that labour can be saved by making one application instead of several. Many different mixtures are made, but there has been some standardisation of farm compound fertilisers during and since the last war. Many compounders to-day produce their mixtures in the modern granulated form; this obviates the trouble of "setting" and "caking" and ensures freedom and evenness of flow in combine-drills. If granulation is not conducted, special attention must be paid to pre-conditioning in the factory, and inert or mainly inert "fillers" are often used to obtain a friable condition.

Some farmers still mix their own compounds but great care is needed to ensure efficiency of mixing; an uneven mixture inevitably produces uneven crop growth. Modern mixing plant is at a great advantage compared with the old hand methods and it is very doubtful to-day whether home-made mixtures are economic. The cost of farm labour and laborious hand methods may well be greater than the factory cost, and the manufactured compound is constantly checked for efficiency of mixing since it has to conform to the statutory regulations of the Fertiliser and Feeding Stuffs Act. It may, however, be advantageous for a farmer to mix "straights" himself if he requires, and cannot obtain, a special balance of nitrogen, phosphates, and potash. However, some manufacturers make special mixtures to customers' requirements; such mixtures are unlikely to be in granulated form since granulation is a continuous rather than batch process.

National Compounds—In co-operation with the Ministry of Agriculture, the fertiliser compounders manufacture several compounds of an agreed analysis, and these are available in most parts of England and Scotland. In addition there are a number of regional or local mixtures, some of which may be available in various districts. In case of difficulty in finding supplies of one of these mixtures, farmers are recommended to contact the regional centre of the National Agricultural Advisory Service; each N.A.A.S. region maintains liaison with the fertiliser industry and full information about the compound fertilisers is available. Besides these standard mixtures, a number of proprietary mixtures are made.

Analyses of some of the National Compounds (1951/52) are as follows :—

TABLE 35.

	Nitrogen per cent.	Sol. phos. acid per cent.	Insol. phos. acid per cent.	Potash per cent.
No. 1A. ...	8·0	5·5	0·5	10·5
No. 5A. ...	4·0	6·5	3·5	8·0
No. 7A. ...	—	12·25	0·75	13·0
No. 9A. ...	9·0	8·5	0·5	—

Concentrated Compound Fertilisers (C.C.F.)—A special range of high analysis compounds is offered by Imperial Chemical Industries Ltd. in granular form. At present (1951/52) the principal analysis is :—

Nitrogen per cent.	Sol. phos. acid per cent.	Insol. phos. acid per cent	Potash per cent.
12·0	11·5	0·5	15·0

Fertiliser Mixing—In general, compound fertilisers used in farming are based upon mixtures of sulphate of ammonia, superphosphate, and muriate of potash. Ground rock phosphate or steamed bone flour can also be introduced if an increase in the insoluble phos. acid content is desired. A farmer mixing his own compounds is well advised to keep to these materials for they can be brought together without any risk of chemical inter-actions that would cause loss of nutrient value. Sulphate of potash can be safely substituted for muriate of potash. The organic " straights " like bone meal, hoof and horn, and dried blood can also be safely included. These further possibilities should cover the main needs of growers of intensive crops. Lime, lime carbonate, or other alkaline materials should on no account be mixed with sulphate of ammonia or superphosphate. Alkaline materials cause the evolution of gaseous ammonia from sulphate of ammonia; with superphosphate they " revert " the water soluble phosphates into insoluble phosphates. Basic slag is an example of a straight fertiliser which would act in this way. It is inadvisable to include nitrates in home-made mixtures. They absorb water fairly readily and cause stickiness of condition. There is also a risk of nitric acid formation. Nitrates should never be mixed with organic matter ; in particular ammonium nitrate should not be used by farmers in making compounds as it is an explosive chemical requiring special precautions.

Mixtures of sulphate of ammonia, superphosphate, and potash form a set a day or two after mixing. This change has no adverse effect upon plant-food content or availability. In factory production, the set is allowed to occur and the large heaps are then re-pulverised before final bagging ; special conditioners are also used as filler materials. For home-made mixtures, steamed bone flour is often used to provide some of the phosphate content because it is also an excellent " anti-setting " ingredient, but the price is relatively high and supplies are scarce. Farmers are advised to mix their requirements in small amounts to permit almost immediate application ; the mixture can thus be used before appreciable " set " takes place. In fertiliser factories the adoption of modern granulation methods has overcome the problem of setting, but this method requires large and costly plant and cannot be imitated on the farm.

It is insufficiently realised that even mixing depends upon the various ingredients having a fairly even particle size. In factory compounding, this is ensured by first milling all the ingredients, thus reducing the " lumpier " materials to much the same fineness of size as those in good, fine condition. However much effort is put into hand mixing, large and heavier particles are certain to segregate whenever the mixture is moved in bulk or even to some extent in filling or emptying bags.

In calculating the amounts of fertiliser materials required to provide specific mixtures, two methods can be employed. A farmer may simply decide to apply, say, 1 cwt. of sulphate of ammonia, 3 cwt. of superphosphate, and 1 cwt. of muriate of potash per acre ; in such cases, he will merely mix the three materials in those proportions. Rather more arithmetic is involved if he wishes to obtain a final mixture of a specific analysis. Should he require 5 per cent. of nitrogen in the mixture, then with sulphate of ammonia, which contains 20·6 per cent. nitrogen but for this purpose should be regarded as 20 per cent. for simple calculation, he obtains the amount as follows :—

$$\frac{\text{X cwt.}}{\text{20 cwt.}} = \frac{\text{5 per cent.}}{\text{20 per cent.}}$$

$$\text{Therefore, X} = \text{5 cwt.}$$

In short, the final mixture must contain 5 cwt. of sulphate of ammonia per ton. Similarly, if 8 per cent. of sol. phos. acid is required and 18·0 per cent. superphosphate is being used.

$$\frac{X \text{ cwt.}}{20 \text{ cwt.}} = \frac{8 \text{ per cent.}}{18 \text{ per cent.}}$$

Therefore, X = 8·88 cwt., say 9 cwt.

Or, a ton of the mixture must contain 9 cwt. of the superphosphate.

It will be found, of course, that there is a limit to the total analysis obtainable ; clearly, not more than 20 cwt. of ingredients can be put into 1 ton of mixture. For some analyses less than 1 ton of fertiliser ingredients in all is required to make 1 ton of the mixture ; an inert filler must then be added to make up the difference. Sand is probably the most likely filler a farmer could cheaply and readily obtain. It is important that any such filler should be free from lime or limestone or other alkaline matter. Peat, if not too coarse, would be a good filler and would diminish the setting tendency. However, this problem of including a filler is best avoided for home-made mixtures.

Cumbersome tables are often given to show which fertiliser materials may or may not be mixed with one another. This shortened table covers those materials which farmers are likely to obtain for home-mixing to-day :—

The following must NOT be mixed with superphosphate, sulphat of ammonia, ammonium phosphate, or triple superphosphate

Basic slag.
Nitro-chalk.
Any form of lime or limestone.
Wood ashes.
Sewage sludges containing lime.
Nitrates of soda or potash *except* in fairly small relativ amounts. (It is unwise to use nitrates at all in home made mixtures as these materials absorb water s readily.)

The Plant-feeding functions of Fertiliser Nutrients—Th three principal plant-foods are nitrogen, phosphorus, an potassium. While their functions in plant-growth are inter connected, they are considerably different. A simple knowledg of these functions enables the grower to select appropriat fertilisers and obviates wasteful applications.

Nitrogen is the plant-food for size and "greenness" o plant. It is the primary nutrient for stem and leaf size an for the rate at which these grow. Slow growth of leaf and yellowness of colour are symptoms of nitrogen shortage.

Phosphorus is the plant-food for root development. It i therefore required at an early stage of plant growth. Sinc the assimilation of all soil nutrients proceeds through th roots, phosphate deficiency resulting in poor and slow roo growth can lead to general deficiencies even though othe plant-foods are present in the soil. It is therefore important to apply phosphatic fertilisers at the time of, or before, sowing and planting. Research using radio-active phosphorus made into fertilisers (enabling the phosphorus taken up by the plant to be followed in its later plant movements by the radiation emitted) has shown that most of the phosphorus taken up by cereals from fertiliser dressings is taken up at an early stage of growth. Phosphatic fertilisers also hasten ripening. For fodder and grazing crops, the extra phosphorus assimilated (extra, that is, to the poor amounts that would be assimilated in growth under phosphate deficient conditions) will add to the mineral feeding value of the crops, a point of considerable importance for dairy herds whose milk production removes large amounts of phosphorus.

Potassium plays a general part in plant nutrition. It appears to control the balanced functioning of other nutrients, particularly of nitrogen, thus giving the plant more health and vigour. Nitrogen in the absence of adequate potash may lead to soft, lush growth with poor resistance to adverse weather, etc. It is also considered that potassium confers greater resistance to diseases and pests, though this view should not be pressed to extremes ; it is more accurate to say that potassium deficiency will reduce a plant's natural resistance qualities. Potassium is an important nutrient for tuber or fruit production, e.g., potatoes, apples, etc. Not only does it stimulate plants to produce the carbohydrate substances and sugars built up in these parts of the plant, but when—as with fruit—there is a ripening stage, potassium encourages early ripening.

While the recognition of deficiencies in growing crops requires expert knowledge for certainty of diagnosis, the following simple characteristics may be useful :—

Nitrogen deficiency—Fairly easy to diagnose. Growth of plant generally poor. Short and thin shoots. Small leaves with pale green or yellow-green colour, later developing highly coloured tints especially on older foliage.

Phosphorus deficiency—Can be confused with nitrogen deficiency. Growth of plant also generally restricted, but a dull bluish-green leaf colour (rather than the yellowish-green for nitrogen deficiency) is characteristic of phosphorus starvation. Tints developing later are in the bronze-purple range and less vivid in colour than the later tints for nitrogen shortage. Strong purple tints develop in cereals. The diagnosis of phosphorus deficiency is more difficult than that of nitrogen.

Potassium deficiency—Thin shoots which often die back. Discolorations of the foliage especially in the portions between veins ; these show first on older leaves owing to the fact that newer growth is drawing upon the potassium held in these first-grown parts of the plant. Brown spots on leaves near the edges are characteristic. Crops which show poor and delayed development of the flowers after having otherwise made reasonable progress should be particularly suspected for potassium deficiency.

FERTILISER PRICES AND VALUES—Fertiliser prices have recently advanced appreciably. From 1939 onwards subsidies were increasingly paid to manufacturers in order to prevent steady rises in price, but in 1949 it was announced that these subsidies would be withdrawn in two stages, i.e., part in 1950 and the remaining part in 1951. The first stage of de-subsidisation took place on 1st July, 1950, with a consequent rise in price of mineral and compound fertilisers broadly amounting to 25–30 per cent. The second stage of de-subsidisation took place on July 1st, 1951.

It is customary to calculate fertiliser values as unit values, i.e., the cost of 1 per cent. of nitrogen (N), or 1 per cent. of soluble phosphoric acid (P_2O_2) or 1 per cent. of potash (K_2O). The cheapest sources of these nutrients are generally taken for this purpose, i.e., sulphate of ammonia, superphosphate, and muriate of potash. This basis of calculation is often unfair to other types of fertiliser. For example, nitrate forms of nitrogen or organic nitrogen will always be dearer per unit than the nitrogen in sulphate of ammonia, and for purposes in which these other forms of nitrogen are advantageous a farmer must expect to pay more for the same amount of the plant-food. Similarly, in working out the unit values of a compound fertiliser, a farmer must bear in mind that the price or the compound also includes the costs of mixing and bagging, and mixing may also cover the process of granulation. Futhermore, and this applies particularly to compounds used in intensive or market garden cropping, the ingredients mixed may be dearer and (for their special purpose) superior sources of the plant-foods, e.g., some dried blood or hoof and horn as the source of some or all of the nitrogen content, or sulphate instead of muriate as the source of potash. It is not legally required of a manufacturer that he should state the ingredients used in making a compound fertiliser, but where the price per ton is above the usual level for the declared analysis in terms of nitrogen, phosphoric acid, and potash, reputable firms usually state, in their own interests, the special ingredients which have been incorporated. Indeed, if information of this kind cannot be obtained, the buyer has some right to be suspicious that the higher price may not be justified.

The prices of most mineral fertilisers are subject to maximum price control by the Board of Trade. The system is complicated since prices vary according to tonnage of consignment and to time of delivery, rebates being given to encourage early intake on the farms. It is convenient to give here those prices which operated for 6-ton consignments delivered in the period Feb.-June, 1952. Surcharges applied to smaller consignments and a sliding scale of rebates for some fertilisers applied for deliveries made before February.

TABLE 36.

Fertiliser	Price for delivery to nearest station to farm	Analysis	Price per unit
Nitrogenous fertilisers :	£ s. d.	(Nitrogen) per cent.	s. d.
Sulphate of ammonia	15 15 0	20·6	15 4
Nitro-chalk	14 11 0	15·5	18 10
Phosphatic fertilisers :		(sol. phos. acid) per cent.	
Superphosphate* ...	14 13 6	18·0	16 4
Basic slag	10 2 0	18·0	11 3
		(insol. phos. acid) per cent.	
Ground phosphate rock	12 2 0	29·0	8 4
Potassic fertilisers :	(Price at store) £ s. d.	(potash) per cent.	
Muriate of potash ...	20 4 0	60·0	6 9
Sulphate of potash ...	22 7 6	50·0	8 11

N.B.—For analysis variations, which sometimes occur for superphosphate, the potash fertilisers, and widely for basic slag, there are controlled price additions or subtractions. For a fully detailed account of the price variations for analysis changes, loads smaller than 6 tons, etc., the farmer should refer to S.R.O. 1951, No. 1017, issued by the Board of Trade and obtainable from H.M.S.O.

*NOTE.—A variation introduced into the 1951 Price Control Order was that 20s. per ton could be added to the price for superphosphate if it was in granulated form. A similar addition was not, however, permissible for compound fertilisers in this form.

Compound Fertiliser Prices—For analyses of some National Compounds, see page 80. The standard prices, i.e., the price for a 6-ton consignment delivered to the nearest station in Feb.-June, 1952, were :—

National Compound No. 1A—£20 1s. 6d.
National Compound No. 5A—£18 2s. 0d.
National Compound No. 7A—£20 6s. 0d.
National Compound No. 9A—£19 11s. 0d.

The price of the C.C.F. type of compound fertiliser (in which the phosphoric acid is based upon ammonium phosphate) as described on page 80 is £26 14s. 6d.

Other compound fertilisers, that is to say the wide range of analyses offered by various manufacturers, are also subject to maximum price control. To the price at which similar fertilisers were sold during the period May-June, 1951, additions may only be made according to a fixed scale, as follows :—

(1) a standard addition of £1 10s. 9d. per ton,
plus (2) 3s. 3d. for each 1 per cent. of nitrogen.
7s. 10d. for each 1 per cent. of sol. phos. acid ;
3s. 6d. for each 1 per cent. of insol. phos. acid ;
1s. 7d. for each 1 per cent. of potash if derived from muriate ;
1s. 2d. for each 1 per cent. of potash if derived from sulphate.

These permissible additions cover the effects of the second stage of de-subsidisation. The system is clearly complex and not easy for a farmer to check, but in broad terms it may be said that price rises of about £3 0s. 0d. per ton over the similar prices for 1950/51 are involved.

Residual Values of Fertilisers—Compensation is usually payable to an outgoing tenant for the residual fertility derived from his application of fertilisers during occupation. Until 1946 the general system for calculating such compensation was based upon tables compiled by Voelcker and Hall and proportions of the actual prices paid for various fertilisers were allowed, those proportions being calculated according to the known residual values of the particular fertilisers concerned. This long-standing system was revised in 1946 at a Conference called by the Ministry of Agriculture ; the new recommendations of this Conference were accepted by the N.F.U., and by Landowners' and Land Valuers' organisations.

Instead of values based upon proportions of the prices paid for various fertilisers, the unit value system was introduced. Thus, in working back to assess the value of fertilisers applied, it is necessary to have records of their analysis as declared under the Fertilisers and Feeding Stuffs Act.

The residual values allowed are as follows :—

TABLE 37—RESIDUAL VALUES

	GROWING SEASONS		
	After One	After Two	After Three
Nitrogen			
(*a*) Inorganic N* ...	nil	nil	nil
(*b*) N in dried blood	nil	nil	nil
(*c*) Organic N, other than dried blood	one-half	one-quarter	nil
Phosphoric acid			
(*a*) Soluble	two-thirds	one-third	one-sixth
(*b*) Insoluble... ...	one-third	one-sixth	one-twelth
(*c*) Total in bone products ..	one-half	one-quarter	one-eighth
(*d*) Total in other materials ...	one-third	one-quarter	one-twelth
Potash			
(*a*) Total K_2O ...	one-half	one-quarter	nil

*By inorganic N, fertilisers like sulphate of ammonia, nitro chalk, nitrate of soda, etc., are implied.

The various fractions in the columns above represent the values left in the soil ; they are converted into £ s. d. values by the use of unit values for the previous fertiliser dressings. At the time this Conference met these were the values :—

Nitrogen, 10s. per unit.
Phosphoric acid, 6s. per unit.
Potash, 5s. per unit.

These values were, of course, based upon the prices then prevailing for fertilisers. The recent price rises of 1950 and 1951 must affect these unit values. It was, however, recommended that they should only change as a result of fertiliser price alterations in jumps of 2s. per unit for nitrogen or 1s. per unit for phosphoric acid and potash. Taking the 1950 prices as from 1st July, it would seem that the following unit values should operate for future residual value estimations :—

Nitrogen, 14s. or 16s.
Phosphoric acid, 16s.
Potash, 7s. (although the new unit value on the basis of price at stores is only 6s. 9d., when delivery is added the value is several pence higher).

At the time of compiling these notes, no official statement had been made about revising this system in consequence of raised fertiliser prices.

Salt as a Fertiliser—Though it has long been known that salt dressings are beneficial to mangolds, the role of salt as a fertiliser for certain crops has only recently been recognised. The value for mangolds was loosely attributed to the fact that this species was originally a marine crop. Research during the war showed that salt dressings increased yields of sugar beet and the output of sugar per acre considerably. It is now recognised that certain crops have a special need for *sodium* as a nutrient and hence the fertiliser value of salt is due to its sodium content. Sodium is not an essential nutrient even for these crops, which can be grown without it ; but it might be called essential for their maximum cropping.

This is of great importance to sugar beet growers for the application of 3 to 5 cwt. of salt per acre applied before sowing produces from 3 to 4 cwt. extra yield of sugar per acre. This effect is additional to the yield increases produced by normal fertilising unless nitrate of soda has been used as the source of nitrogen, in which case the salt dressing should be at least halved ; being a sodium-containing fertiliser a useful proportion of the sodium needs of the crop will already have been supplied.

Other crops which benefit from sodium, though not so spectacularly as mangolds and sugar beet, are cabbages, kale, and barley. On light and poor soils, wheat and oats will often respond to salt. The effect is less certain on heavy soils.

Table for Fertiliser Applications—Recommendations are sometimes given in terms of cwt. per acre when pounds per rod or ounces per square yard would be preferable for small-scale use. This conversion table simplifies the necessary arithmetical conversions.

TABLE 38—CONVERSION TABLE FOR RATES OF APPLICATION.

Per acre	Per rod	Per sq. yd.
1 cwt.	11 oz.	½ oz.
2 cwt.	22 oz.	¾ oz.
3 cwt.	2 lb.	1 oz.
4 cwt.	2¾ lb.	1½ oz.
5 cwt.	3½ lb.	2 oz.
8 cwt.	5¾ lb.	3 oz.
10 cwt.	7 lb.	3¾ oz.

N.B.—The smaller weights are given to the nearest convenient unit of measurement and are not precisely accurate.

Lime, Limestone and Liming—British soils have a strong tendency to develop acidity. The annual loss of free lime per average acre of grass and arable land is estimated to be 1½ cwt. of pure lime. The effects of soil acidity are multiple. Iron and aluminium enter the soil solution and proceed to fix (i.e., lock up in insoluble chemical compounds) the available phosphate present. Essential soil bacteria are discouraged and adverse bacteria are encouraged. Soil structure may deteriorate. The useful activities of earthworms are greatly reduced since worms thrive poorly in acid soils. Though a few crops are tolerant of acid soil conditions and a number of weed species seem to thrive upon them, it may be taken to be a rule of good farming to apply liming materials to all soils as soon as acidity is indicated, preferably when the indication has come from proper sampling and testing. There are certain dangers which may arise from over-liming, notably the creation of trace-nutrient deficiencies, e.g., of manganese, but for every acre in Britain where this hazard is possible there must be 10,000 acres where the lime status is too low for over-liming to be regarded as a real risk. If soil testing precedes liming, the amount of lime or limestone needed to bring the soil to a suitable condition can be estimated with fair accuracy.

Although the use of lime has been established for many centuries, the acid state of British soils in the "thirties" was so serious that it was officially estimated that 15½ million tons of lime were needed for the soils of England and Wales alone. The Land Fertility Scheme of 1937 introduced a subsidy scheme for lime used in farming. By 1949 16 million tons of lime, or its equivalent in limestone and waste limes, had been applied to English and Welsh soils. But most of this tonnage had merely held in check the annual lime losses due to rain and crops, and a fresh estimate of the total lime needs in 1950 has revealed that 14 million tons of lime are still required to bring English and Welsh soils out of a state of high or moderate acidity. It is clear that lime is still seriously under-used despite the fact that the present (1951) subsidy scheme covers half the cost of the lime, and its delivery to farm. With the rise in price of fertilisers, attention to liming is even more important to the economics of a farm; for most mineral fertilisers are considerably less efficient when applied to acid soils.

At one time undue attention was paid to the different qualities of various limestone sources. Since the fundamental problem is the neutralisation of acids in the soil, a purely chemical attitude to lime and limestone is quite sufficient. The value of a liming material is expressible as the amount of acid it will neutralise.

Limestone or chalk are natural deposits liberally found in this country. They may contain 94–97 per cent. by weight of calcium carbonate ($CaCO_3$). It was once considered essential to burn these materials in kilns, thus producing *burnt lime* :—

$$CaCO_3 \rightarrow CaO + CO_2$$

Limestone) (Lime) (Carbon dioxide gas)

This burnt lime absorbed water avidly with heat generation, and sometimes water was added in a further process to produce *slaked or hydrated lime* : $CaO + H_2O \longrightarrow Ca(OH)_2$. This slaked lime is very finely divided and is the most " comfortable " type of lime to handle. However, the kiln and slaking processes add considerable cost to the material, especially to-day when labour and fuel costs have risen. It is not yet sufficiently realised by farmers that pulverised natural limestone or chalk—ground limestone—is a most effective material for neutralising acids in soils. Roughly twice the amount is needed by comparison with burnt lime, but this is offset by its much lower price and with modern machine spreading the labour involved in the greater amount per acre required is not much greater. The relative " lime values " of these materials can all be expressed quite simply in their lime or equivalent lime contents ; as a rough generalisation it can be said that burnt limes contain 90–95 per cent. of lime, ground limestones contain from 48–52 per cent. of lime (equivalent), and hydrated lime contains from 68–72 per cent. of lime. Generally, therefore,

1 ton of burnt lime = 1½ tons of slaked lime = 2 tons of ground limestone.

In quickly reducing soil acidity, the amount of general contact between the soil and the lime dressing is important. Lumpy types of liming material are not as efficient as finely-divided types. This is one of the advantages of ground limestone for it can be evenly and finely pulverised. Burnt lime on the other hand, steadily absorbs moisture and, however finely ground after leaving the kiln, its particles will tend to adhere together after exposure to damp air. Tests in recent years have shown that, for equivalent lime values, ground limestone is *not*, as was often supposed, slower in reducing acidity.

Prices of lime and limestone vary according to districts and proximity to quarries and lime works. At source, lime materials are very cheap but transport charges add appreciably to the final cost per ton on the farm, as is the case with all low-price materials.

It should not be forgotten that the old name for superphosphate—" superphosphate of lime "—misled many farmers to suppose that this fertiliser contained free lime. It does not ; all the calcium is already combined either as phosphate or sulphate of calcium, and these substances have no acid-neutralising value.

In some areas various waste limes from industry are available, e.g., gas lime, lime from sugar-beet processing, etc. These materials should be judged on their lime or lime equivalent contents and also upon their physical condition.

It is often argued whether liming is best conducted in the autumn or the early spring. Chemically, the best time is probably in the very early spring, but the lime needs of our soils are in general so great that it is justifiable to say that " any time is better than no time." Liming should, of course, precede fertiliser application and sowing or planting.

ARABLE CROPS

ROTATION OF CROPS

Crops must not be regarded as separate entities but as part of a system designed to utilise the potentialities of soil and climate to best advantage. Moreover, by so doing great economies in cultivation, labour and manuring can be effected. Repeated cropping, with one type of crop encourages the establishment of weeds and favours insect attacks and fungoid diseases. By adopting a sequence of different crops the land is rested and time allowed for natural control of disease or insect pest. Moreover " cleaning " crops like potatoes or sugar beet can be interspersed with corn crops which do not permit the amount of cleaning operations to be carried out.

A well designed rotation also evens out the rush period during the season, spreading seed time and harvest over as long a period of time as possible and reducing slack periods to a minimum. Shallow rooted crops can be alternated with deep rooting plants, restorative crops like peas, beans and clovers with the more exhaustive cereals. Not all crops are suited to all types of soil and hence a choice must be made from those which are best suited to the specific conditions of any particular farm. Nor is it wise to have all one's eggs in the same basket, and for this reason most farmers adhere to rotational cropping in spite of a tendency in modern times to crop the land solely with an eye to market probabilities.

The most widely practised rotation in this country to-day is the four course or " Norfolk Four-course " as it is usually termed, consisting of roots, barley, seeds, wheat. It is most applicable to the medium and lighter classes of soil, but can be easily modified to suit a wide range of requirements.

Other well-tried and well-balanced rotations are given in the following table :—

TABLE 39—TYPICAL ROTATIONS

3-Course	4-Course		5-Course	
			High Proportion	
Rich Fens and Silts	Light Land	Heavy Land	Sales Crops	Grass
Wheat	Roots	Bare Fallow	Roots	Roots
Potatoes	Barley	Wheat	Barley	Barley
Sugar Beet	Seeds	Beans	Seeds	Seeds
	Wheat	Wheat	Wheat	Seeds
			Oats or Barley	Wheat

6-Course			7-Course
Heavy Loams	To include Potatoes	High proportion Sales Crops	General for Average Land
Beans	Roots	Roots	Roots
Wheat	Barley	Barley	Oats
Oats or Barley	Seeds	Barley	Seeds
Seeds	Oats	Seeds	Seeds
Wheat	Potatoes	Wheat	Seeds
Barley or Oats	Wheat	Oats or Barley	Seeds
			Oats

In recent years the long ley has come to be regarded as the pivot of the rotation rather than the root crop and greater and greater emphasis has been placed upon it. After a period of recuperation under ley arable cropping can be carried out economically as regards manuring and weed control. This alternation of ley with arable has for long been known in the north of Britain as "Alternate Husbandry." More latterly the term Ley Farming has been adopted. The system requires adequate fencing and water supplies in all fields and reasonably ploughable land and for these reasons cannot be carried out indiscriminately all over the country.

CATCH CROPPING

Consists of snatching an extra crop between two of the main crops of the rotation without interfering with the normal system of farming. For instance, Italian ryegrass undersown in say wheat can be grazed after harvest and throughout the autumn and winter until ploughed up the following spring prior to sowing a spring cereal such as oats or barley. Another example is the sowing of turnips or crimson clover on a disced corn stubble in the autumn immediately after harvest. Such a crop provides early spring keep for sheep before it is ploughed up for mangolds or quick growing turnips. Mustard is sometimes sown on fallow land for ploughing in, whilst Italian ryegrass sown after early potatoes are lifted is often ploughed down in the autumn for green manure.

TURNIPS AND SWEDES

Require similar treatment and thrive best in cool, moist climate on lighter to medium types of soil. In hot dry weather the " fly " and mildew are troublesome.

Varieties—

White turnips ... ... (8 per cent. dry matter)	Lincolnshire Red, Greystone, Pomeranian White.
Soft Yellow Turnips ... (9 per cent. dry matter)	Fosterton Hybrid, Early Sheep Fold.
Hardy Yellow Turnip ... (10 per cent. dry matter)	These are hardy and frost resistant and closely resemble swedes. Aberdeen Yellow in both green top and purple top strains. The Bruce (purple top), the Wallace (green top), show resistance to " finger and toe " disease.

Swedes are usually classed as purple, bronze or green tops.

Purple Skin ... ... (11 per cent. dry matter)	Eclipse, Magnificent, Majestic, Purdy's Purple Top, Tipperary, Magnum Bonum.
Bronze Skin ... ... (12 per cent. dry matter)	An intermediate type. Mancunian, Lord Derby, White-fleshed.
Green Skin ... ... (13 per cent. dry matter)	Keepwell, Wilhelmsburger.

Classification of Turnip and Swede Varieties.

Variety	Average per cent. dry matter	Order of Merit Keeping quality	Yield
Soft White Turnips	7½–8	6	6
Soft Yellow Turnips	8½–9	5	5
Hardy Yellow Turnips... ...	10½	4	4
Purple Skinned Swedes ...	11½	3	1
Bronze Skinned Swedes ...	12	2	2
Green Skinned Swedes ...	12½	1	3

Cultivations—Autumn cleaning of the stubble is advisable followed usually by the application of dung unless applied in the rows in the spring as in the wetter districts. Crops should be grown on ridges in wetter districts and on the flat in dry areas.

Seeding—Turnips, three lb. per acre ; swedes, four lb. per acre. One lb. of seed is ample under good conditions. Swedes are sown from the middle of May to middle of June—turnips in June. Best width of drill is 27 in. on ridge or 20–24 in. on the flat.

Singling—Single as soon as first rough leaves are formed to 10 in. in the row, and inter row hoe as frequently as necessary.

Manuring—Lime is essential and in all cases where regular liming is needed the root break is a convenient point in the cropping to make good this deficiency

Farmyard manure ...	15 tons per acre applied in autumn or spring.
Sulphate of ammonia ...	1 cwt. per acre when dung not available.
Superphosphate	4 cwt. per acre.
Muriate of potash ...	1 cwt. per acre.

Harvesting—White turnips are ready in September and the soft and hardy yellows follow in sequence with the swedes coming last about November.

Roots must be protected from frost either by ploughing in or lifting and clamping. Topping and tailing should not be drastic or keeping quality will be impaired.

Average yield per acre—White turnips, 12–14 tons ; yellow turnips, 14–16 tons ; swedes, 15–20 tons.

Number of seeds per 1 lb.	140,000 to 200,000
Weight of seed per bushel	50 lb.
Weight of roots per bushel ...	42–45 lb.

MANGOLDS

Suited to dry sunny districts and deep rich loam soils. Varieties classified according to shape, globes, tankards, intermediate and long. Colour differences exist within each group. The dry matter content—and hence the feeding value—shows marked variation between varieties and selection should be made on this basis. In trials carried out by the National Institute of Agricultural Botany, the variation in dry matter content was of the order 15·1 to 7·3 per cent.

Cultivations—The crop may be grown on the ridge or the flat. It prefers a fine, firm, stale seed bed. Dung is best applied in the autumn and ploughed in.

Seeding—6–10 lb. per acre in rows 26–28 in. on the ridge and 20–22 in. on the flat. It is an advantage to soak the seed for 2 hours before sowing. Time of seeding varies from mid-April in the midlands to mid-May in the south. Gaps in a field may be filled by transplanting.

Singling to 10 in. should take place as soon as the first rough leaves are formed—usually about six weeks after drilling.

Manuring—In addition to say 20 tons per acre farmyard manure, the following mixture is suggested :—

	cwt. per acre
Sulphate of ammonia	1
Superphosphate	2
Steamed bone flour	1
Muriate of potash	1
Common salt	3
	8

The salt should not be mixed with the other fertilisers but applied separately 3–4 weeks before drilling. After singling 1–2 cwt. per acre nitrate of soda can be applied to advantage.

Harvesting—Mangolds must be lifted and in safe storage before danger of frost is imminent. The tops are screwed off by hand, the roots are not trimmed. Mangolds may be clamped with the tops left on provided this is done when they are dry.

Yield—20–50 tons per acre. Mangolds should not be fed until after Christmas or they may give rise to scouring in stock.

KOHL RABI

This crop is especially suitable for districts subject to drought and on stiff loam soils. May be used for folding or feeding indoors. Not suited to cold wet soils. Highly resistant to "finger and toe" disease.

Varieties—Two varieties are commonly grown, one in which the leaves and bulbs are glaucous green, the other being reddish-purple. There is little to choose between them.

Cultivations—These follow the same lines as for mangolds though the crop is always grown on the flat in rows 20–24 in. apart. Seedlings may be transplanted.

Seeding—The seed is sown in April at four lb. per acre, and plants are later singled to one ft. in the rows.

Manuring—in addition to 15–20 tons dung per acre, the following mixture of fertilisers should be applied :—

	cwt. per acre
Sulphate of ammonia	1
Superphosphate	2
Steamed bone flour	1
Muriate of potash	1
	5

After singling the crop benefits from a top dressing of nitrate of soda at one cwt. per acre.

Harvesting—The roots stand frost and can be left growing until required, or they may be lifted and stored like swedes.

Yield—20 tons per acre.

CARROTS

Require a deep, sandy soil though they do well on peaty and fen soils.

Varieties—Red Altrincham is the heaviest cropping variety with good cooking quality. Stump-rooted varieties are best for shallow soils and the bunching trade, and Scarlet Intermediate for general purposes. White Belgian because of its very high yielding propensities is commonly grown for stock feeding.

Cultivations—The seed bed must be clean and very fine, firm and moist.

Seeding—The seed is drilled in rows 12–20 in. at 5–6 lb. per acre from mid-April onwards. A little barley or oats may be sown with the carrot seed to indicate the position of the rows and enable early inter-row cultivation to commence. The seed may be soaked before sowing to encourage germination, and this may even have started. It may be mixed with sand to facilitate drilling.

Owing to the danger of carrot flies being attracted to the crop, thinning is not usually carried out since bruised plants by virtue of their pungent smell tend to attract the fly. Later in the season, rough thinning may be carried out to supply the bunch trade. Early in September slight earthing up may be carried out to cover the shoulder of the roots and prevent them greening.

Manuring—Dung is best applied to the previous crop or danger of fanged roots may arise. Liming, though not essential, is advisable in cases where an appreciable deficiency exists.

The following mixture of fertilisers is suitable for general purposes :—

	cwt. per acre
Sulphate of ammonia	1
Superphosphate	2
Steamed bone flour	1
Muriate of potash	1
	5

When the plants are 2–3 in. high it is advisable to top dress with nitrate of soda at one cwt. per acre.

Harvesting—The crop is usually ready from August onwards but the main crop is not lifted as a rule until October. The roots should be under cover before frost is likely, and can be clamped in a manner comparable to potatoes.

Yield—10–12 tons per acre. On ploughed-out grassland 20–25 tons per acre is not uncommon.

POTATOES

The crop can be grown satisfactorily on most types of free working soil, especially those rich in organic matter. The best cooking quality is secured when the crop is grown on the Old Red Sandstone and limestone soils. Being subject to frost damage, early potatoes can only be grown satisfactorily in coastal districts, such as the south-west of Scotland, Pembrokeshire and Cornwall.

Varieties—Varieties are classified as "first earlies," "second earlies," and "lates or main crops." Varieties in common use are tabulated below :—

TABLE 40—Varieties of Potatoes

Name	Shape	Colour of Flesh	Depth of Eyes	Cropping Capacity	Cooking Quality
First Earlies					
Arran Pilot* ...	Kidney	White	Shallow	V. Good	Good
Epicure ...	Round	White	Medium	Good	F. Good
Ulster Chieftain*	Oval	White	Shallow	V. Good	Fair
Ulster Prince* ...	Kidney	White	Shallow	V. Good	Good
Home Guard* ...	Oval	White	Shallow	Good	F. Good
Second Earlies					
Eclipse	Oval	White	Shallow	Good	F. Good
Great Scot*	Round	White	Medium	Good	Good
Craig's Royal* ...	Thick Kidney	Cream	Shallow	V. Good	V. Good
Lates or Main Crops					
King Edward ...	Kidney	White	Shallow skin—splashed pink	Moderate	Excellent
Majestic* ...	Kidney	White	Shallow	V. Good	Good
Kerr's Pink* ...	Round	White	Deep pink skin	Excellent	Good
Redskin* ...	Round	White	Shallow pink skin	V. Good	Good
Arran Banner*	Flat Round	White	Medium	Excellent	Good
Gladstone* ...	Oval	White	Shallow skin—splashed pink	Good	Excellent
Arran Peak* ...	Thick Oval	White	Shallow	V. Good	Good
Ulster Supreme*	Oval	White	Shallow	Excellent	Good

* Immune to wart disease.

Seed Certification—Maximum yield is dependent upon the use of healthy, virus-free seed, and it is customary in districts where aphides are common to use new seed each year, or every other year. To ensure healthy seed a system of certification is used by the Agricultural Departments in the United Kingdom and Eire. Certificates are of three kinds : " SS " (Stock seed) which is seed of the highest grade intended mainly for seed production, " A " (first quality commercial seed) and " H " (healthy commercial seed). After the certificate letter, the country of origin is indicated thus : Scotland " (Scot)," England " (E)," Wales " (W)," Northern Ireland " (Nor. Ir)," Eire " (Eire)," or Isle of Man " (I.O.M.)." Finally, " N.I." is added in the case of those varieties which are not approved as immune from Wart Disease. Thus a certificate designated " A (Scot) " would indicate seed potatoes of first quality, commercial standard, grown in Scotland, and of a variety immune from Wart Disease ; " H (E) N.I.", healthy, commercial seed potatoes grown in England, but of a variety not approved as immune from Wart Disease.

The field inspection standards adopted by the several Departments for the issue of these certificates are now in very close agreement.

The attention of all seed potato merchants and growers is drawn to the Seeds (Amendment) Regulations, 1944, which lay down a new classification for seed potatoes and set out the particulars which must be stated on every sale or exposure for sale of seed potatoes in England and Wales.

The new classification is divided into the three groups (1) " certified," (2) uncertified (English or Welsh once-grown)—an intermediate group for seed potatoes obtained from an uncertified crop which was grown in England and Wales from a " certified " stock, and (3) " uncertified." In the case of the " certified " classes, the reference letters and numbers of the relative certificate must be quoted. The full classification is :—Certified (Scotch), Certified (Northern Ireland), Certified (Eire), Certified (English), Certified (Welsh), Certified (Isle of Man), Uncertified (English once-grown), Uncertified (Welsh once-grown) ; Uncertified (Scotch), Uncertified (English) and Uncertified (Welsh).

When ordering seed potatoes, growers should state the variety, class of seed, country of origin and size of tuber required. As a rule one ton of seed is required to plant an acre of ground. For earlies planted in 24 in. rows with a foot between the setts 25 cwt. may be required, whilst for main crops planted 16 in. apart in the row, with 28 in. rows, 18 cwt. may be plenty.

Size of Seed—The most economical size of seed potato is comparable to a hen's egg, and will weigh about 2 oz. Each tuber may be cut into small pieces, each of which should contain at least one healthy sprout. When cutting tubers it is advisable to leave the cut sections in a cool, dark place for a few days before planting. This allows a protective layer of cork to form over the cut surface.

The practice of sprouting seed potatoes leads to higher yields per acre, and is to be encouraged. For this purpose the tubers should be boxed as soon after lifting as possible and kept over winter in a glass chitting-house, or other well lighted room where the temperature can be maintained above 40° F.

Normally potatoes occupy part of the root break in the rotation, but in certain parts of the country where conditions are very favourable for their growth, rotations which grow a higher proportion of potatoes are followed.

Cultivations—In cultivation a deep, friable tilth should be obtained.

Manuring—Farmyard manure, which is well suited for potatoes, should be applied and ploughed in prior to cultivating, or it may be applied in the rows immediately before planting. In addition to dung for second earlies and main crops, the following fertiliser mixture is advisabie :—

	cwt. per acre
Sulphate of ammonia	2
Superphosphate	3
Muriate of potash	1½
	6½

For earlies, which have to be forced to maturity rapidly, 10 cwt. per acre or more of a compound fertiliser may be given. The following is a common mixture used in many of the early districts :—

	cwt. per acre
Sulphate of ammonia	4
Superphosphate	5
Muriate of potash	1
	10

Planting—Planting may be done by hand or machine, main crops being planted at the end of March onwards. About two weeks after planting, light harrows can be run over the land to level the ridges and kill small weeds, and inter-row cultivation will continue as long as it is possible without damaging the plants.

Lifting—Lifting will commence in early districts at the end of May, whilst main crops will be lifted from September onwards.

The traditional method of storing is in clamps, but equally satisfactory is the use of sheds or barns, where a mere covering of straw to protect the tubers from frost is all that is necessary.

Yield—The average yield per acre varies from 6–8 tons. but on good soils in favourable seasons, 16 tons per acre or more may be obtained.

CABBAGE

The large number of varieties available may be grouped as follows :—

Early varieties—Winningstadt, Early Drumhead, Early Express, Early Sheepfold, Enfield Market.

Seed sown March, transplanted April to May, ready for cutting August to September.

Seed sown May, transplanted June to July, ready for cutting October.

Seed sown August, transplanted October, ready for cutting July.

Late or Main crop varieties—Cattle Savoys, Drumheads Late Ox-hearts.

Seed sown March, transplanted April to May, ready for cutting November onwards.

Seed sown nursery bed August, transplanted in October ready for cutting in July or transplanted following April and ready for cutting from September to December.

Quantity of seed per acre—Four lb. per acre in rows 24–30 in apart. Single to 18–24 in.

Sown in nursery bed one lb. of seed supplies sufficient plant for an acre of land. When plants are purchased 5,000 to 10,000 per acre are required according to spacing. Advent of efficien mechanical transplanter has greatly increased practice of transplanting.

Suited to stiff soils, and forms a capital fallow crop for such Considered by some superior to turnips for feeding purposes.

Manuring—Responds to generous manuring. In addition to farmyard manure (up to 20 tons per acre) the following mixture of fertilisers should be applied prior to sowing or planting out :–

	cwt. per acre
Sulphate of ammonia	1–3
Superphosphate	3–5
Muriate of potash	1

During the growing season two–three top dressings o nitrogenous fertiliser at one cwt. per acre usually prove wort while. Being " cleaning " crop, cabbages usually occupy part o the root break.

Yield—On good land 30 tons per acre, but up to 60 tons ca be obtained. For early varieties, 20 tons per acre.

RAPE

Grows on a wide range of soils, succeeding best in the cool amp districts of north and north-west. Subject to mildew in ild climates.

Varieties—The varieties grown may be Giant Rape having nooth leaf and long tap root and most suitable for land in good eart or Essex Dwarf with a rough leaf and fibrous root suitable r the heavier classes of land.

Used frequently as a catch crop it produces keep three months fter sowing. Often sown in mixture with soft turnips or ustard or ryegrass.

Cultivations—These usually follow the lines adopted for any oot crop.

Manuring—In addition to dung the following mixture of rtilisers may be applied prior to sowing the seed :—

	cwt. per acre
Sulphate of ammonia	1
Superphosphate	2
	3

If dung is not available one cwt. per acre of sulphate of mmonia may be given in addition.

Seeding—Seeding takes place at any time from March to eptember, sowing in rows 10–12 in. apart at 2–4 lb. seed per cre or broadcasting at 10–12 lb. per acre. Sown as a nurse rop for seeds, it should not exceed two lb. per acre. The yield er acre of green fodder is in the region of 10 tons per acre.

KALE

Marrowstem Kale has been produced by crossing Kohl-rabi nd thousand-headed Kale. It is usually grown as part of the oot break and thrives on a wide range of soil conditions, referring deep soils in a state of high fertility.

Thousand-headed Kale is a much-branched plant with numerous lain, uncurled leaves. It withstands more severe winter onditions than Marrowstem Kale and for this reason is usually eserved for feeding after Christmas, by which time Marrowstem ale has become woody and fibrous and low in feeding value.

Rape Kale and **Hungry Gap Kale** are hybrid varieties grown in manner comparable to the other Kales, but being particularly seful for feeding in late spring and even until June.

By using all the types of Kale mentioned it is possible to ecure a succession of succulent feed from September to June.

Cultivation—Usually these crops are grown in rows 20–24 in. apart on the ridge or on the flat, sowing four lb. of seed per acre from March onwards. Thinning to a foot between plants in the rows subsequently takes place. Both Marrowstem Kale and thousand-headed Kale are frequently sown broadcast. The seed may be sown in a nursery bed and the plants transplanted under favourable weather conditions. One pound of seed provides an adequate number of plants for an acre of ground. This metho has the advantage of good control over turnip flea beetle sinc adequate protection from the pest can be given in the nurser bed by dusting with an insecticide and, moreover, it permit cleaning operations to continue until planting out takes place.

Manuring—The Kales are gross feeders and in addition t farmyard manure—up to 20 tons per acre if available—th following fertilisers should be applied prior to sowing th seed :—

	cwt. per acre
Sulphate of ammonia	1–3
Superphosphate	3–5
Muriate of potash	1

Additional nitrogenous fertiliser applications may be justifie when heavy yields of very leafy crops are required.

Singling—When grown in rows inter-row cultivation continue as long as possible without damaging the crops. Singling wi commence as soon as the first rough leaves are formed, but a increasing number of farmers now leave the crop unthinne in the row.

Kales may be folded off by cattle or sheep or the crop may b cut and carted home for housed cattle. Folding with the aid an electric fencer is becoming increasingly popular owing to th low cost of labour involved. Marrowstem and thousan headed Kale make excellent silage when chopped and this particularly useful for feeding late in spring.

Yield—The average yield of Marrowstem Kale is 20 tons p acre, but with generous fertiliser treatment 40 tons per acre is n uncommon. Thousand-headed Kale usually yields about 10–1 per cent. less than Marrowstem Kale.

MAIZE

Maize may be grown for green fodder or ensiling in distric subject to drought. White Horse Tooth is excellent for fodde Jaune Gros du Domaine for ensiling, whilst Compton's Ear matures early and is well adapted for late districts and f either purpose. Early Leeming and Eureka are early maturi varieties of recent introduction.

The seed should be sown when danger of frost is over (mi May to mid-June) at 56-84 lb. per acre, 2 inches deep, in ro

20 inches apart. The manuring should be generous and comparable to that given for Kale.

An average crop gives 20-25 tons per acre of green crop. Good crops yield 35 tons.

LUPINS

Lupins may be grown on poor land for green manuring. White, yellow and blue varieties are available. The Sweet Lupin has been used for forage.

Seeding in April 60-120 lb. per acre in rows 20 inches apart, or may be broadcast.

If grown for seed cut before fully mature to prevent shedding. Yield of seed 12-18 cwt. per acre.

SUGAR BEET

Soils—Can be cultivated successfully on many soils especially sandy soils, loams, silts and peat. Heavy soils in wet districts are not suitable but beet can be grown on heavy loams if care is taken to lift and cart off early in autumn. Deep, friable soils with ample rainfall during the growing season and a dry autumn to complete maturity and allow easy carting off constitute ideal conditions.

Varieties—Three main types distinguished by their field behaviour with regard to root size and sugar percentage.

(*i*) E type. Heavy tonnage of roots with a relatively low sugar content.
(*ii*) Z type. Smaller yield of roots with a relatively high sugar content.
(*iii*) N type. Intermediate in these two characters.

The National Institute of Agricultural Botany, Huntingdon Road, Cambridge, is responsible for testing the commercial stocks of sugar beet, and periodically issues reports on their respective merits. General experience has shown that E type stocks are the most profitable to grow although on Fen soils, where the roots reach a very large size, the strains richer in sugar are favoured.

Quantities of seed per acre—18-20 lb. for March and early April sowings, 15 lb. for mid-April and 12 lb. for sowing late April and May.

Time of sowing—Early sowing gives better yields: experiments have shown that a crop drilled in early April produces about two tons per acre more beet than when sown at the beginning of May. Beet may be sown from mid-March onwards if good seedbed conditions prevail and sowing should be completed in April except in late districts.

Weight of seed per bushel—24 lb. **Seed in 1 lb.**—30,000 (approx.).

Average weight of one root—1½–2½ lb.

Average yield per acre—9–10 tons. Good crops up to 18 tons. The average sugar content is about 15½ per cent. and the basal price per ton of washed beet paid by the factories is for roots of this sugar content : a higher rate is paid for roots richer in sugar content than 15½ per cent., and deductions are made if the sugar content falls below this figure.

Fodder Beet is a recent introduction into British Agriculture being the product of crosses between sugar beet and mangolds and of selections from high-yielding sugar beet types. On the Continent, whence most of the strains used in this country derive, the term "fodder beet" is used to cover all types of Beta spp. used for fodder.

The classification of strains at present adopted in this country follows the Danish system and uses the percentage of dry matter in the root as its basis :—

Sugar beet for Fodder	... over 20% D.M.	Hunsballe, Pajbjerg.
Fodder Sugar Beet	... 15-20% D.M.	Red Øtofte, Pajbjerg Rex.
Mangolds (Barres types)	... less than 15% D.M.	... Barres Øtofte Barres Strynø.

Compared with mangolds, fodder beet normally gives a higher yield of dry matter per acre ; this results from the higher dry-matter content of the roots and a much larger yield of tops. On the other hand, it is more difficult to lift, clean and top.

Except for harvesting, the cultivation of the crop follows the same lines as for mangolds.

Root yields for the higher dry-matter types average about 18 tons per acre ; the yield of tops varies considerably, but averages about 10 tons per acre.

In this country, fodder beet is utilised to a large extent in pig feeding ; it can also be fed to cattle and horses.

Cultivations—Sugar beet usually follows a cereal in the rotation : the roots penetrate deeply and subsoiling may be necessary if there is a pan. Normally, ploughing 10 in. to 12 in. deep provides the tilth for the production of shapely and easily harvested roots. One-way ploughing is better than ridge and furrow work as it keeps the surface of the land level for ease and efficiency of the subsequent inter-row cultivations. Ploughing should be completed before Christmas especially on soils where it is difficult to obtain a fine seedbed without plenty of frost action.

Manuring—The crop fails at about *p*H 5.3 and the soil reaction should be as near to *p*H 6.5 as possible : if the soil is acid lime must be added to lime requirement but not to excess as symptoms of manganese and boron deficiency may develop if the soil is very alkaline.

Farmyard manure is specially valuable and experiments have shown that even a small dressing of 6–10 tons per acre will increase the yield by two tons of roots per acre even with a large balanced dressing of fertilisers. A suitable dressing for average loam soil in addition to dung is :—

	per acre
Superphosphate (18.5 per cent. water soluble P_2O_5)	3–5 cwt.
Muriate of potash	1–2 cwt.
Salt	4 cwt.
Sulphate of ammonia or Nitrate of soda	3 cwt.

The higher figures for potash and phosphate apply to soils very deficient in these elements or where no dung is given. Salt is a plant food for beet and invariably increases yield even in the presence of potash. It should be ploughed in during the winter or broadcast in the spring at least three weeks before sowing. The remainder of the dressing of fertilisers should be applied to the seedbed : trials have shown that there is nothing to be gained by top-dressing except on light soils or on unthrifty crops or where the field is very weedy in which case the application of all the nitrogen before drilling may stimulate weed growth and make singling difficult : top dressing should not be done later than singling, otherwise the sugar content may be reduced.

The seedbed—The sugar beet " seed " is really a fruit containing up to four true seeds ; thus although the clusters are relatively large, the true seeds are very small and have only a small reserve of plant food. The seedbed must, therefore, be fine and moist to allow the seed to establish itself quickly and firm in order that the seed shall be in close contact with the soil and will not dry out during germination. The aim should be a fine layer of soil about 1 in. deep overlying a well worked but firm tilth upon which the seed can be deposited. It is important that the seed should be compressed into this firm layer of soil, either by rolling after drilling or by fitting single wheel rollers to the drill set to run behind the drill coulters.

Plant population—In the cultivation of the crop, the continuous line of seedlings is thinned out as for mangolds, and the number of plants left to grow on and produce the crop is a most important factor in determining the yield of roots. At least 25,000–30,000 plants per acre should be left, the higher figure for all except the most fertile soils where slightly fewer plants will often be successful. Table 41 gives the theoretical plant population at different row widths and singling distances. This gives the *maximum* possible plant and takes no account of subsequent losses during horsehoeing or from the depredation of rabbits or destruction by insect pests.

TABLE 41

Singling Distance	ROW WIDTH									
	15	16	17	18	19	20	21	22	23	24
8	52,300	49,000	46,100	43,600	41,300	39,200	37,300	35,600	34,100	32,700
9	46,500	43,600	41,000	38,700	36,700	34,800	33,200	31,700	30,300	29,000
10	41,800	39,200	36,900	34,800	33,000	31,400	29,900	28,500	27,300	26,100
11	38,000	35,600	33,500	31,700	30,000	28,500	27,200	25,900	24,800	23,800
12	34,800	32,700	30,700	29,000	27,500	26,100	24,900	23,800	22,700	21,800
13	32,200	30,200	28,400	26,800	25,400	24,100	23,000	21,900	21,000	20,100
14	29,900	28,000	26,400	24,900	23,600	22,400	21,300	20,400	19,500	18,700

Although a plant population of 30,000 can be theoretically obtained equally well by singling 24 in. rows at 8 in. spacing, the leaving of so many plants in the row is difficult to achieve in practice, and a rather wider singling distance combined with 18–21 in. rows is best. 15 in. rows have been shown to produce the highest yields, but the increases gained by narrowing the row width to this extent are not sufficient to compensate for the extra difficulty in cultivation. Wider rows than 21 in. are only justified on foul land.

Row crop cultivations—These have three main functions :—

(*i*) To destroy the weeds which would otherwise compete with the beet and reduce the yield.
(*ii*) To prepare the crop for the operation of singling.
(*iii*) To clean the land for the benefit of the whole rotation.

Small beet seedlings are very sensitive to weed competition and the first hoeing, cutting as close to the rows as possible, should be done as soon as the rows are visible across the field. Usually two hoeings are necessary before singling, and three or four afterwards until the development of the roots and foliage makes further operations impossible without causing damage. The equipment used for the row crop cultivations must be the same width as the drill to avoid cutting up plants along the joins of the drilled rows : horse-drawn implements or toolbars mounted on tractors may be used. The ideal outfit must not only allow lateral movement for accurate steering but should have independently mounted and sprung hoe blades so that the same depth of working is maintained regardless of irregularities in the ground level. The first cultivation should be deep and close to the rows, the later ones using A hoes working shallowly in between the rows.

Singling—The ideal stage is when most of the plants bear four leaves. Singling later than this causes serious reductions of yield and the longer the delay the greater the loss. Singling is normally piecework and the most satisfactory basis of payment is per 100 yard run of row, which automatically allows for differences in row width. Singling may be performed in one operation by long-handled hoe or, as in some districts, notably the Fens, the crop is first bunched by a long hoe and then singled by hand. A few doubles left after singling do not decrease the yield but cause extra work at harvest and hinder mechanical harvesting and should be singled at the second hand-hoeing which is carried out about a month after singling.

Beet crops may be bunched mechanically by hoeing across the rows or by gapping machines which travel along the row. Only very regular stands of seedlings can be treated in this way or a loss of plant population results. The effects of bunching mechanically are to make singling quicker and to allo delay of about a week in singling without loss in yield.

Harvesting—The harvesting of the crop is determ by the contract with the British Sugar Corporation and entails a continuous supply of beet to the factory from the week in September until the factory closes, usually at the of the year although the campaign may extend into Jan Over this long period yield and sugar content alter and alth the weather, particularly the rainfall, may cause a diff pattern of crop development in some years, as a rule s variations are noted. During the latter end of Septembe crop increases in weight at about half a ton per acre per This falls off in October and November, but growth may take place in December if the weather is open. Sugar centage also increases during late September and early Oc and reaches its peak at the end of October; thereafter it

Lifting—There are three methods of lifting.

(*i*) Hand forking. This is only used on small acreag

(*ii*) The roots are loosened by a horse or tractor lifter, then pulled by hand, knocked to remove th and laid in rows ready for topping. The tops are se from the roots with hand choppers.

(*iii*) A number of machines have now been developed fo mechanical harvesting of sugar beet. These equipm may either consist of a single machine which per the complete operation of lifting, topping and kno or two machines, one which tops the beet in the gr followed by another which lifts the topped bee windrows them.

Protection of Beet from Frost—Frozen beet lose rapidly; left growing in the field they are not af except by very severe and prolonged frost, but once lifte roots are susceptible. In frosty weather, small heaps o should be covered with tops, large roadside heaps with or hedge trimmings.

By-Products—In addition to the cash return fro sale of the roots, growers of sugar beet benefit from th products of the crop which form valuable food for st

Sugar Beet tops—The tops consist of the green and crowns of the roots; they contain 15–17 per cent matter, which is rich in protein and sugar, and are a sub for the usual root crops. Although analysis shows tha beet tops have the same nutritive value as 40 lb. of m their utilisation is attended by some waste, consequently quantities of tops and mangolds must be fed to ob same live weight increase. Care should be taken to ke as clean as possible because sand can be highly dangerous e digestive system of the stock. The weight of tops per is, on the average, almost equal to the weight of washed delivered to the factory. When wilted the tops lose about rd of their weight. Fresh beet tops contain oxalic acid n causes scouring, but by allowing them to wilt for a week, concentration of oxalic acid is greatly reduced: as an onal precaution about ¼-lb. precipitated chalk to every lb. of tops should be fed.

ature sheep eat 14–21 lb. of tops daily: as a rough guide, re of tops will feed 100 sheep for a week. A ewe flock lo well from October to January on beet tops with little than a good supply of hay and a run out to grass until to lambing.

10-cwt. bullock can consume 100 lb. of tops daily and, ugh cattle can rarely be finished on beet tops because the runs out early in the New Year, tops can be used in the stages of fattening and are especially valuable for feeding e pastures when the cattle are waiting to go into their r fattening quarters. Care must be taken in feeding tops ry cows because of an impurity, betaine, which may taint milk. No taints in milk should develop if the ration of does not exceed 40 lb. per day, fed, not in the cow house, n pasture immediately after the morning milking. Surplus which cannot be fed fresh, can be conserved either by g or ensilage. Drying tops is practised in Germany and s are now being made to develop the process in this y. The tops must be washed to free them from adherent r collected in a very clean condition and the crowns must redded to permit drying at a temperature which does not the leaves. Sugar beet top silage is best made in a pit onsolidation is necessary. No molasses are required, but important to have good drainage as beet tops are very nd a large quantity of liquid is expressed during ensiling. ilage is palatable and up to 60 lb. per day can be fed ry cows: 7 lb. hay, 40 lb. sugar beet top silage and 4 lb. provide for the maintenance of a dairy cow and the first of milk.

gar Beet pulp—The residue from the sliced roots the sugar has been extracted is dried and is sold back grower, either as beet pulp or with molasses added as sed beet pulp. This dried pulp is a carbohydrate conte which experiments have shown to be equal in feeding to oats. It may be fed as such to dairy cows or fattening up to 4 or 5 lb. per day or it may be used to replace (4–6 lb. replacing 40 lb. of roots). The pulp should be d in half its own weight of water before feeding.

The factories have sufficient drying plant to dry all but a smal proportion of the pulp they produce. The remainder is sol as wet pulp. Wet pulp is a valuable succulent food for a cattle and keeps well if clamped or ensiled, 1 lb. having a feedin value equivalent to 1½ lb. mangolds.

PESTS AND DISEASES—See pages 195 to 214.

WHEAT

Winter Wheats

1. *Varieties suited to heavy soils of high fertility*—Holdfas Hybrid 46, Jubilégem, Nord Desprez, Redman, Vilmorin 2 Warden, Yeoman.
2. *Varieties suited to heavy soils of intermediate fertility*- Bersée, Juliana, Rivet, Staring.
3. *Varieties suited to heavy soils of low fertility*—Rivet.
4. *Varieties suited to medium soils of high fertility*—King I Holdfast, Hybrid 46, Jubilégem, Nord Desprez, Redma Scandia II, Squarehead II.
5. *Varieties suited to medium soils of average fertility*—Bersé Juliana, Steadfast, Squarehead II, Squarehead's Maste Wilhelmina, Pilot, Staring.
6. *Varieties suited to medium soils of low fertility*—Little Jos Squarehead's Master.
7. *Varieties suited to light soils*—Little Joss.

Spring Wheats

1. *Varieties for soils of high fertility*—Atle, Bersée.
2. *Varieties for soils of medium fertility*—Fylgia, Meteor.
3. *Varieties for soils of low fertility*—April Bearded.

Manuring depends upon place in rotation. After roots fallow merely nitrogenous top-dressing ; after ley farmya manure is commonly applied ; after straw-crop 1 cwt. ammo ium phosphate in combine drill or sulphate of ammonia 1-1½ cw superphosphate 2-3 cwt., muriate of potash ½ cwt.

Quantity of seed to sow per acre, 2 to 3 bushels = 9 to 1 stones, in drills 6 in. to 9 in. apart, and 1 in. to 1½ in. dee Weight per imperial bushel :—Average of experiments Rothamsted with 26 varieties of wheat over a period of 8 yea 61¼ lb. Ministry of Agriculture average 62·3 lb. Average Edinburgh market for 13 years, 62·2 lb. Average head wheat 20 spikelets ; each spikelet 3 grains, total head 60 grai Average yield of grain per acre (1940-49), 19·1 c Average yield of straw 25 to 30 cwt. Proportion of grain straw, 1 to 1½. Proportion of dressed corn to tail corn, 10 to

Wheat is suited to heavy stiffer soils but some varieti e.g., Little Joss, are definitely light soil wheats. Sown af seeds, beans or fallow. Rivet is definitely a cold, clay s variety. One quarter of wheat weighing 500 lb. yields on grinding—

	lb.		Per cent.
Flour	380	=	76·0
Bran	26	=	5·2
Middlings	50	=	10·0
Sharps	34	=	6·8
Loss	10	=	2·0

Wheat succeeds best in dry climates and is accordingly found to the greatest extent in eastern districts of England and Scotland. The chief proteins of wheat are gliadin and glutenin.

BARLEY

The following varieties are commonly grown—

Two-row, broad-ear varieties : Plumage-Archer, Plumage, Camton ; two-row narrow-ear varieties : Spratt-Archer, Earl, Golden-Archer, Kenia, Maja, Ymer, Freja, Pioneer ; six-row : Prefect, Bere (in Scotland).

Varieties for the heavier classes of soil of medium to high fertility—Plumage-Archer, Kenia, Maja, Ymer, Freja.

Varieties for light to medium soils of average fertility—Spratt-Archer, Golden-Archer, Earl, Kenia, Maja, Ymer Freja.

Quantity of seed per acre—2½ to 4 bushels = 1¼ to 2 cwt. per acre ; if drilled 6–9 inch drills, 2 to 2½ bushels = 1 to 1¼ cwt. per acre. Optimum time of sowing February to middle of March ; for winter sorts, early October.

Weight of bushel, 56 lb. Average head, 32–36 grains. Proportion of kernel to husk, 90 per cent. to 10 per cent. Average yield of grain per acre (1940-49), 17-8 cwt, Average yield of straw per acre, 20 to 25 cwt. Proportion of parts : grain, 50 per cent., straw, 50 per cent.

Barley is suited to medium to light soils, preferably with a good lime content. Frequently grown after a root crop but not uncommonly after wheat. It has a well-developed but not very deep root system and in consequence a fine seed bed is essential. Manuring needs special care to secure malting sample. Usually 2-4 cwt. superphosphate and 1 cwt. muriate of potash per acre. Nitrogen is seldom given except when barley follows a cereal when ¾ to 1½ cwt. sulphate of ammonia may be justified.

Barley malt is made by immersing the grain in water for from 45 to 65 hours and then allowing it to germinate on a malt floor. During this time enzymes are liberated within the grain, one of which dissolves the matrix of the cells of the grain in which the starch granules are embedded, and thereby facilitates the action of diastase at a later stage. The plumule and radicle of the germ also develop, the latter with many rootlets. When this process is advanced to the requisite stage the grain is dried at a sufficiently high temperature to cause a suspension of germination without killing the enzymes ; it is then screened to remove the rootlets, and in this condition is known as malt. In the process of malting small amounts of dextrine and maltose are formed but the main change of starch into soluble sugars is effected by diastase in the brewing mash tun. About 35 per cent. of the proteins or nitrogen compounds are also rendered soluble and appear in the final beer in this condition. The malting operation occupies 10 to 15 days.

OATS

Classification of the principal varieties of oats—

(*a*) Spring varieties, *white grain*—Blenda, Craig's Afterlea, Eagle, Early Miller, Glasnevin Ardri, Glasnevin Triumph, Maldwyn Marvellous, Milford Minor, Onward, Potato, Resistance, S. 84, Sandy, Star, Stormont Arrow, Stormont Iris, Stormont Kern, Sun II, Victory, Yielder ; *yellow grain*—Golden Rain II ; *black grain*—Black Tartarian, Supreme.

(*b*) Winter varieties, *black grain*—Black Winter, Bountiful ; *grey grain*—Grey Winter ; *white grain*—Picton, S. 147, S. 81, S. 172, Unique.

A. strigosa, or bristle-pointed oat, is found mainly in the Western Isles, Shetlands and in Wales where selected strains have been introduced ; this species is used largely on uplan soils and the whole crop, straw and grain in a green state, i fed to livestock.

Proportion of husk to whole grain, 20 to 35 per cent.

1. *Varieties suited to the most fertile soils*—Craig's Afterlea Eagle, Elder, Glasnevin Ardri, Milford Minor, Resistance, S. 84 Stormont Arrow, Stormont Iris, Sun II, and, where earlines is important, Supreme and Yielder.

2. *Varieties suited to soils of intermediate fertility*—Early Miller, Golden Rain II, Maldwyn Marvellous, Onward Potato (in districts of high rainfall), Star and Victory.

3. *Varieties suited to soils of low fertility*—Bell, Blac Tartarian, Sandy, Stormont Kern, Grey Winter.

After roots or ley manuring seldom necessary, after stra crop fertilise as for wheat.

Quantity of seed to sow per acre for common varieties 3 to 6 bushels = 1¼ to 2¼ cwt. per acre in drills 6 to 9 in. apa or broadcast. Optimum time to sow : October for winte and February to March for spring varieties, usually after le or another cereal. Average yield of grain per acre (1940-49 16·8 cwt. Average yield of straw, 20 to 30 cwt.

RYE

Winter and spring varieties occur but in this country sprin varieties are seldom grown. The winter varieties used ar King II, Pearl and English.

Quantity of seed to sow per acre, 2–3 bushels. Optimum owing time September and early October. For soiling and heep folding sow up to 4 bushels per acre in August or eptember. Weight per bushel, 54 lb. Number of grains per ushel at 55 lb., 1,161,600. Average yield of grain per acre, 4·1 cwt. Average produce of straw per acre, 35–40 cwt. roportion of parts 32 per cent. grain to 68 per cent. straw y weight.

Suits poor and light sandy soils and will grow up to 1,200 et above sea-level. Often grown on peat land where oats ould lodge. Should be cut for grain only when dead ripe. ill not "shatter" readily. For soiling should be cut nmediately after it shoots ; often mixed with tares for soiling r sheep folding. Straw tough and wiry ; excellent for thatching : cross-fertilised in contra-distinction to the other English reals which are self-fertilising. The chief proteins of the ain are gliadin and glutenin but, unlike wheat, gluten is not ormed when the flour is mixed with water.

MIXED CORN

Mixed corn is frequently sown where conditions are unvourable for straight cereals. "Dredge" is usually a ixture of barley and oats and "Mashlum" one or more reals but chiefly oats with beans or peas. The total seeding about 15-16 stones per acre and the cultivation follows e lines already indicated for the cereals.

BEANS

Varieties are divided into winter and spring groups, the tter ripening 2-3 weeks later, the former having the better llering capacity. Specific varieties have not yet been developed ut research is in progress.

Seed rate is 1½ cwt. per acre for winter beans and 1¾ cwt. r spring-sown varieties. May be drilled in rows 7 or 21 inches part or broadcast and ploughed in, usually between two corn ops or in place of clover ley. Crop does well on ploughed ut grassland. Sowing dates mid-October or mid-February. hief manurial requirement is for phosphate. Soil must be ell supplied with lime. Dung is beneficial and, in addition, r most soils 6-10 cwt. per acre basic slag or 4-5 cwt. superosphate with 1 cwt. muriate of potash. Average yield grain 16 cwt. per acre but 30 cwt. not uncommon. Straw elds 25 cwt. per acre.

PEAS

The crop may be grown for (*a*) stock feeding, (*b*) packing, (*c*) picking green. Varieties for (*a*) Grey or Dun, Maple, artridge, Prussian Blue ; (*b*) Harrison's Glory, Large Blue, Marrowfat ; (*c*) Laxton, Onward, Lincoln, Gladstone. Seeding usually February-March at 1¾ cwt. per acre in rows 9-12 inches apart and 2 inches deep. Seed should be dressed with organo-mercuric powder to prevent rotting in the soil. In favourable districts sowing in October-November is successful. Lime is essential. For average conditions 4 cwt. per acre superphosphate and 1 cwt. per acre muriate of potash is adequate. Average yield grain 13·2 cwt. per acre, 20-25 cwt. straw. Green peas yield 70 bags (40 lb.) as first earlies, 120 bags second earlies and 150 bags for main crops.

VETCHES OR TARES.

Winter and spring varieties are listed but little is known of the difference between them. The former are regarded as the hardier. Grown mainly for forage either alone or in mixture with cereals. The land should be manured as for peas. Winter vetches are sown September-October, spring vetches from February to April, using 1½ cwt. per acre of seed. Bird scaring may be necessary. More commonly grown in mixtures (see pages 156-157).

Grown alone, vetches produce 12-18 cwt. of seed per acre.

BUCKWHEAT

Two cultivated species—*Fagopyrum esculentum*, common buckwheat ; *Fagopyrum tartaricum*, Tartarian buckwheat.

Under *Fagopyrum esculentum* there are three varieties Common, Silver Grey and Japanese which differ in the heigh and bushiness of the plant, and in the colour and shape o the seed.

Seed of Common buckwheat is dark brown, triangular in cross-section, and with sharp angles, while in varieties o *tartaricum* the seed is longer with rounded angles and wavy outline, and greyish in colour.

Quantity of seed to sow per acre, 1 to 2 bushels = 4½ to stones per acre ; sown from middle to end of May. Buckwheat is very susceptible to frost damage. Yield of grain per acre, 10–12 cwt. according to fertility of soil. Grain approximates oats in composition, but has a slightly highe fibre content ; is valuable for poultry feeding.

FLAX

Cultivated species—*Linum usitatissimum*, *L. angustifolium* and *L. crepitans*.

The latter two species are cultivated to a limited exten abroad but *L. usitatissimum* supplies the flax and linseed o commerce, and is the only species grown in the British Isles.

L. usitatissimum comprises two major groups—the see flaxes, and the fibre flaxes, the former being characterised by much branched habit of growth, later maturity, shorter stem and higher seed yield than the latter in which the stems are unbranched for the greater portion of their length.

Flax is only grown on contract for processing factories and the seed is supplied to the grower by the factory. Varieties commonly grown are Stormont Gossamer, Stormont Cirrhus, Liral Monarch, Liral Prince and Norfolk Earl.

Quantity of seed to sow per acre, 6 to 8 stones. Sow mid-March to mid-April in southern England, in northern districts mid-April to mid-May, drilling is preferable ; preparation of land before sowing should aim at a fine, firm, clean seed bed and the seed should be lightly harrowed in and rolled to encourage even and prompt germination.

Weight of seed per bushel, 56 lb. Number of seed per lb., 108,000. Average produce of straw per acre, 2·3 tons. Average produce of seed per acre, 4 cwt. Average produce of scutched fibre per acre, 30 stones.

In the crop rotations flax is generally taken after a white straw crop or after lea. Best suited to medium loams ; on land which is too fertile fibre quality is inferior and the crop tends to "lodge." It is usually grown on the reserves of plant food in the soil.

Flax should be pulled at the time when the basal stem-leaves start to fall off and tied into round sheaves or butts. After drying they are immersed in soft water to ret. The retting process is continued long enough to enable the fibre bundles to be readily separated from the other stem tissues when scutched, but if continued too long the individual fibres of the bundles tend to separate on scutching and much tow will then be produced.

LINSEED

Recently Canadian varieties Redwing, Royal and Bison have proved suitable for growing in this country. Of these Redwing ripens first and is best suited for late districts whilst Royal gives the better yields of seed.

As with flax the crop is grown usually on plant food reserves n the soil. On potash deficient land 1 cwt. per acre muriate of potash may be applied. Linseed can be sown broadcast at 120 lb. per acre or drilled at 80 lb. The seed should not be buried deeply, ½–1 in. being ample in most cases. It is well uited for growing on ploughed out grassland being relatively mmune to wireworm attack and rabbit damage.

The crop should be cut when the seed in the ripest capsules s plump, shiny and pale brown in colour. If cutting is delayed beyond this point much seed is likely to shed. Small sheaves hould be made to facilitate drying and the threshing drum needs careful setting. The straw is useless for feeding or bedding but the chaff can be fed direct or used for making linseed jelly. The yield of seed is usually about 10 cwt. per acre

LUCERNE

Cultivated species—*Medicago sativa.*

In the U.S.A. known by the Arabic name *Alfalfa*.

Seed is mainly obtained from abroad and the variety is i general called after the country of origin, e.g., Provence o Hungarian lucerne. Valuable varieties not named after th country of origin are Du Puits and Grimm.

Mostly grown in the eastern counties where its drought resistant features are of great value.

It is a perennial and where properly managed yields three t four cuts annually for a period of years.

Grows on a wide range of soil types provided the land i clean, well drained and not acid. Phosphatic and, on lig land, potassic fertilisers also should be applied before sowin and annually during the life of the crop. A fine, firm, clea seed bed is essential, and on land which has not grown lucern successfully before, the seed should be inoculated prior t sowing with a root nodule "culture."

May be grown as a pure crop or in association with othe forage species.

Quantity of seed per acre—10–20 lb. ; sown in April with o without a cereal "nurse" crop, or in July without a "nurse crop. Good mixtures are—14–16 lb. lucerne, 1 to 3 lb. cocksfo and ½-lb. wild white clover ; timothy or meadow fesc may be substituted for the cocksfoot. Weight per bushe 60–62 lb. Seeds per lb., 205,000. Average yield of fodd per acre, 10–20 tons, green ; 2–5 tons hay. Average yield seed per acre, 6 bushels.

HOPS

Principal Varieties—These are grouped for marketing purpos as follows :—

1. GOLDINGS—Early Bird, Bramling, Canterbury Goldin Eastwell Golding, Petham Golding, Rodmersham Goldin Mathon.

2. GOLDING VARIETIES—Cobbs, Tutsham.

3. FUGGLE. Over 70 per cent. of the English hop acrea is planted with this variety.

4. NEW VARIETIES*—Early Promise, Northern Brewer, ide of Kent, Brewer's Gold, Bullion Hop, and others.

* Raised by Professor Salmon at Wye College

The hop is a perennial, producing long climbing stems ines) which die down to within about six inches of the root- ock in the autumn ; the basal portions of the stems are used cuttings for propagation. These are grown for the first ar in nursery beds. The hop is dioecious ; the female lorescences (cones) are the "hops" of commerce, but a oportion of male plants are included in plantations as the nes do not develop to their full size unless they are pollinated ; ually 1 male to 200 female plants.

Soil—A wide range but a well-drained slightly heavy loam sting on a porous sub-soil is preferable. Soil-moisture is portant ; hops will not thrive on dry soils.

Spacing and Training—Hops are planted on the square at out 6½ ft. apart or 4 to 5 ft. apart in rows with a space of ft. to 9 ft. between the rows. The bines are trained up coir rn (coconut fibre string) supported on an overhead system wirework at a height of 13 to 14 ft. Two bines are usually ained up each string, the number of strings varying from two four per plant according to the system of planting.

(The new varieties Brewer's Gold and Bullion are very vigorous growth and must be grown with wider spacing, 7 to 8 ft., d high wirework, 14 to 16 ft., and only one bine per string.)

Cultivation—The land is ploughed, throwing the furrows ay from the rows of plants, in spring. In March the top of rootstock is exposed by hoeing and the bases of the evious year's bines are cut off near the rootstock. Culti- tion, commencing at a depth of about 6 inches, is gradually duced in depth and after early July is very shallow. The ses of the bines are earthed-up slightly in June. Autumn atment aims at the prevention of waterlogging the plants flat heavy land by throwing the soil into low ridges with plants on the crest of the ridge. On lighter soils the land ploughed toward the rows of plants in October or November.

Manuring—Should be liberal and, while individual soils y require special treatment, the annual requirements for erage land are :—Nitrogen (N), 250 to 300 lb. ; Phosphoric d (P_2O_5), 230 lb. ; Potash (K_2O), 200 lb. per acre. Sufficient e should be applied to keep the soil in a nearly neutral ndition, *p*H 6.5 to 7.0, and sufficient organic matter to preserve soil structure.

Picking—The hop produces its flowers (" burr ") in mid-July ; the inflorescences develop into cones which ripen early in September. The ripe cones are picked by casual labour paid at an agreed price per basket of approximately one bushel. A bushel of green hops weighs from 5 to 6 lb. Picking takes about three weeks. Average yield 11 to 14 cwt. dried hops per acre.

Drying—Hops are kiln dried immediately after picking, their moisture content being thus reduced from about 80 to about 6 per cent. The hops are placed to a depth of 10 to 24 inches upon a loosely-woven horse-hair cloth supported on an open slatted floor and a current of heated air passed upward through the load by natural convection, or by forced draught produced by a fan. Sulphur is burned below the hops at the commencement of drying to improve the appearance of the hops and to modify their aroma. The temperature is low at the commencement, about 100 F., rising to a maximum of 145 to 155° F. in four to five hours. The process takes about ten hours per load. Two loads are dried in a 24 hour day. The dried hops are pressed into " pockets," about 2 ft. in diameter and 6 ft. in length, each containing approximately 1½ cwt. of hops. These are each marked with a serial number, the name of the grower and the parish and district in which the hops were grown.

Marketing—Hops can, in England, be sold only through the Hops Marketing Board. Each producer is registered with the Board and is allotted a " basic quota," founded on his production of hops in certain datum years ; the ratio of this to the sum of all the " basic quotas " represents the proportion of the brewers' requirements which he is entitled to supply. Each year the estimated demand for hops is apportioned to producer in the ratio of their " basic quotas " ; this amount, which may be the same as, or some percentage of, the " basic quota," i known as the " annual quota." If a producer's crop is les than his " annual quota " he may transfer the balance o the quota to another producer.

Hops are used for brewing and their value for preservativ and flavouring purposes lies in the resins and essential o contained in the lupulin glands—small yellow granules—which are produced within the cone.

GRASSLAND

The grass/legume sward is the most important single crop in Britain ; indeed, this applies to world agriculture as a whole. In our own country not only does grassland occupy the greater acreage of our agricultural land but the grass/legume sward when farmed at its highest potential provides more Starch Equivalent and Protein Equivalent per acre than any other crop. The following table emphasises this point by comparing yields from grassland with *comparative* yields from arable crops.

TABLE 42

	lb. per acre		
	Yield Dry Matter	Starch Equivalent	Protein Equivalent
1. Good grassland cut for hay and aftermath (no stock)— 4 tons as hay ...	8000	3600 (45)*	640 (1·8)*
2. Good grassland grazed (60 cwt. per acre)	6700	4400 (66)	1000 (15)
3. Barley grain (7 qr. about per acre) ...	3300	2600 (80)	230 (7)
straw (1¼ tons) ...	2500	700 (28)	26 (0·8)
4. Beans grain (24 cwt.)	2500	1800 (73)	570 (23)
straw (20 cwt.)	2000	650 (26)	36 (1·8)
5. Potatoes 12 tons per acre yield	7000	5400 (75)	240 (4·5)
6. Mangolds 40 tons per acre yield ...	11000	5500 (50)	342 (3·2)

* Figures in brackets are the percentage S.E. and P.E. respectively from average samples.

The figures given for grassland are not exceptional but represent what might be expected on any farm in lowland Britain. Current experimental work at the Grassland Research Station, Stratford-on-Avon and elsewhere, shows that yields of over 10,000 lb. per acre per annum Dry Matter can be obtained.

Until the beginning of the twentieth century little thought was given to grass and the production of grass as a crop, yet it requires skill in management and maintenance just as does any other farm crop. Following the work of such men as Gilchrist in Northumberland and Stapledon in Wales much more is now known about the establishment, manuring and utilisation of the grass sward. The science of *grassland agronomy* is still relatively young and in many ways is an outcome and an offset of studies in plant ecology (usually studies of a purely botanical nature). Expressed simply, ecology aims at the study of plants and animals as *communities* of individuals. It takes into account the behaviour of the individual, not *as* an individual, but as a member of the community. It also goes further, namely to study the effect of one community of either plants or animals upon neighbouring communities.

It must be stressed that present-day pastures and meadows, whether ley or permanent grass, are in fact *communities* of living plants. Individuals in these communities react upon one another. The grazing animal too has an important influence upon the development of the community of plants, so indeed has the underlying soil. The type of pasture produced is governed by several major factors. Firstly the seeds mixture must be determined, and, secondly, it must be properly established. To ensure this the tilth and other soil conditions must be correct whilst having established the sward, the plants need to be provided with essential nutrients. The use made of the grass and clover ley also influences the sward. All these factors affect the plant community as a whole, and in consequence, the economic return. Quite apart from the direct return from the herbage, the grass sward, by building up an abundant root system, improves among other things, soil texture, perhaps soil porosity and certainly the content of organic matter in the soil. It is upon such information that the crop rotations of the future will be designed always with an eye to building up fertility in the soil and of increasingly up-levelling the yield of arable crops.

In the system of farming now known as "ley farming" the grass sward forms the pivot around which the rotation as a whole revolves. The ley, therefore, offsets the soil exhausting and structure destroying tendencies of the normal arable crop ; arable crops, that is, which tend to deplete particularly the organic reserves in our soils. Recent experiments suggest that the ley promotes crumb structure in the soil with greater efficiency than any other crop. This is particularly so on the more extreme types of soil such as the sands or the clays.

The present-day grasslands of Britain are *man made*. This is true almost everywhere from valley bottom to hill top, so that the landscape of pastures, meadows and rough grazings is maintained in its present condition because of the grazing animals and the way the land is farmed. Once a pasture has been established its character is henceforward largely determined by the manner in which it is grazed and otherwise treated. So the renowned feeding pastures of the Midlands are often full of ryegrass and white clover because grazing has favoured these plants on soils that are themselves of high inherent fertility. A not dissimilar system of grazing applied to homestead fields all over the country has developed similar types of swards with ryegrass and clover dominant.

It is not, therefore, climate nor fundamentally the type of soil which determines the botanical composition and productivity of a pasture. The influence of the soil can be much modified by manuring and the influence of management is clearly modifiable at the will of the farmer. Thus pastures that are dominated by perennial ryegrass, and have been so for many generations on all sorts of soils are found in places climatically as different as East Anglia and the hills of Wales. High up on the Welsh hills the one time cottage gardens (long since derelict as gardens, and, indeed, now often showing no trace of the old cottage buildings) even to-day often carry ryegrass white clover swards, botanically, at least, simulating the best feeding pastures in the country. These little patches of greensward still stand out on the Welsh hills and can be seen for miles in the otherwise brown landscape of the mountain grazings. They provide a constant reminder that the hill lands of Britain call for improvement.

Bearing this in mind, one should not therefore speak of "natural" and "artificial" grassland, but rather of "cultivated" and "uncultivated." The greater part of hill land is "uncultivated," and indeed, a large proportion of the permanent grass fields in the lowlands may be included as "uncultivated." It is, however, difficult to draw a clear cut line between permanent grass and rough grazing. If permanent grass is left untended and uncared for it soon reverts to roughage, and soon goes into the rough grazing class. This state of things is apparent everywhere throughout Britain, although perhaps it was more true in 1940 than ten years later.

Similarly, the transition from " ley " to " permanent grass " cannot be defined with any precision. The question is often asked, " When does a ley become permanent pasture ? " There is no satisfactory answer to this question although one may define the point of transition as that where the species originally sown have been replaced by indigenous grass and weeds. The change from ley to permanent grass often coincides with a fall in productivity of the grass sward. In practice the longer the duration of the ley, the more closely it resembles permanent grass both in botanical characteristics and from the economic point of view. With existing knowledge, however, it is an easy matter to make the ley simulate permanent grass as soon as that ley is well established, that is, within 12 months from sowing. For example, a seeds mixture based on S.23 ryegrass together with wild white clover, if properly established, can closely resemble, botanically at least, a Leicestershire feeding pasture and that within a few months from the day of sowing.

Acreage of Grassland in the United Kingdom—Grass has an importance from many angles and the high proportion of grassland in Britain is shown by the following table.

TABLE 43

ACREAGES ('000's OF ACRES) IN UNITED KINGDOM 1939 AND 1949 IN PERMANENT GRASS, LEYS, ROUGH GRAZINGS AND TILLAGE CROPS.

	1939	1949
Permanent grass	18,773	12,687
Leys (all types)	4,093	5,726
Rough grazings	16,539	17,178
Tillage crops	8,813	12,643
TOTAL ...	**48,218**	**48,234**
Total grass as percentage of whole	81·7%	73·8%

These figures are taken from agricultural statistics. In 1939 81·7 per. cent. of the total was represented by land under grass. The figure for 1949 is somewhat lower at 73·8 per cent. which brings out the material change that has taken place during the stress of war and subsequently. The total area in *permanent* grass has decreased since 1939 and the acreage in tillage crops has increased, while the total acreage in ley has also gone up. With regard to hill grazings little change has taken place from 1939 to 1949 other than a slight increase in the total area returned as rough grazings in 1949.

Before 1939 there were nearly 19 acres of permanent grass for every four acres in ley. There are still more than two acres of permanent grass for every one in ley and these figures demonstrate that more old grassland could be replaced by leys. It should not be an unreasonable objective for the country as a whole at least to reverse the 1949 figures for leys and permanent grass. In other words, while in 1949 there were two acres of permanent grass for every acre in ley, the aim should be for two acres of ley for one in permanent grass. If this target were achieved the effect on the stock carrying capacity of Britain would be very great and in all probability the sheep population could be doubled and present cattle numbers increased by at least a third at the same time maintaining the 1950 production from tillage crops.

Seeds Mixtures—The sowing of grass and clover mixtures has been a part of normal farm practice in Britain for nearly two centuries. Even as early as the seventeenth century agricultural writers advised on seeds mixtures, although little of this advice was accepted in general practice. The early mixtures were largely based on red clover, lucerne, sainfoin and perhaps perennial ryegrass. Later on white clover and trefoil became known. All these early mixtures were very simple in character and were used to provide fodder crops rather than grazed pastures. During the nineteenth century a greater variety of species began to be used and by the beginning of the twentieth century very complicated mixtures were advocated. It was not until the work of Gilchrist became known that mixtures again began to be simplified, and it was about this time (namely the turn of the twentieth century) that the plant breeder began to pay attention to the use of special types or strains among the common herbage plants. Gilchrist, for example, advised his farmers to use New Zealand cocksfoot (the leafy type) while Findlay, in Aberdeen, showed that Welsh red clover (clearly Montgomery red clover) had particularly valuable attributes. Then came the work of Sir George Stapledon and his colleagues at Aberystwyth which culminated in special strains of pedigree grasses and clover, most of which are not only highly productive but very leafy and persistent. These leafy strains provide more flexibility in the production and maintenance of leys. It is now possible to use mixtures of very simple type based, if desired, on only one grass and one clover, or indeed, to simplify still further and have only one species in the pasture. All this has brought nearer the day when the ley can be regarded as a crop designed to fulfil a particular purpose on the farm. Therefore, it is usual to speak of *general* purpose leys and *special* purpose leys, the latter to cater for particular needs at specific times of year. To produce, for example, green grass during the height of the summer drought and to produce high quality grazing at mid-winter.

The following prescriptions by Faunce de Laune, Lord Leicester, Robert Elliott and Arthur Young give some indication of the sort of complex mixture which was being used during the nineteenth century :—

TABLE 44

FAUNCE DE LAUNE'S MIXTURES FOR PERMANENT PASTURE (LB. PER ACRE), ABOUT 1880.

	Good or Medium Soils	Wet Soils	Chalky Soils
Foxtail	10	4	—
Cocksfoot	7	10	14
Timothy	3	3	3
Meadow Fescue	6	3	2
Tall fescue	3	8	—
Crested Dogstail	2	2	5
Rough Stalked Meadow Grass	1½	2	—
Hard fescue	1	1	4
Sheep's fescue	1	—	4
Creeping bent or Fiorin ...	1½	2	—
Yarrow	1	1	2
Golden oat grass	—	—	1
Perennial red clover (Cow-grass)...	1	1	1
Red clover	1	1	—
Alsike (Hybrid clover) ...	1	1	1
Dutch clover (white)	1	1	1
Total lb. per acre : ...	41	40	38

ord Leicester's* Mixture (lb. per acre). About 1800.

ocksfoot	4
erennial ryegrass	2
alian ryegrass	2
imothy	1
all oat grass	1
eadow fescue	2
ard fescue	1
all fescue	1
olden oat grass	¼
lsike clover	1½
hite clover	1
arrow	¼
Total lb. per acre :	17

Lord Leicester is often better known as Coke of Holkham in Norfolk.

Robert Elliott (Clifton Park).
Mixtures for Poor Soils (lb. per acre).
About 1900.

	(A)	(B)
ocksfoot	10	8
all fescue	5	3½
all oat grass	5	3
ard fescue	—	2
rested dogstail	—	1
olden oat grass	—	1
ough stalked meadow grass	1	1
mooth stalked meadow grass	—	1
hite clover	2	2
ed clover	2	1½
lsike	1	1
urnet	8	8
hicory	3	2½
idney vetch	3	2½
heep's parsley	—	1
arrow	1	1
Total lb. per acre :	41	40

ARTHUR YOUNG'S MIXTURE FOR CHALKY HILLS (LB. PER ACRE). ABOUT 1800.

Crested dogstail	3
White clover	4
Burnet	8
Kidney vetch	6
Chicory	4
Ribgrass	4
Yarrow	1
Total lb. per acre :	30

It will be noticed that Italian/perennial ryegrass are either not used at all or if used are employed in very small amounts, indeed it was not until the turn of the twentieth century when Gilchrist evolved his so-called Cockle Park mixture that ryegrass came to be used at dominance in the seeds mixture. During the first half of the twentieth century the Cockle Park mixture with its predominance of ryegrass played an important part in the whole concept of seeds mixture work in this country as well as overseas (e.g., New Zealand). The work of Gilchris promoted simplification as compared with the more comple prescriptions offered by earlier workers but Stapledon advocate still greater simplicity in seeds mixtures and has evolved the ultra-simple mixture employed for a special and specific purpose This is the present state of knowledge. In recent years ther has been a distinct " revolt " amongst certain technical adviser against ryegrass as the dominant species in the general purpos mixture. This is not because ryegrass is less useful than before but its aggressiveness during the first year of a new ley ma suppress other species associated with it, particularly whe these are sown in smaller quantities per acre. The typica Gilchrist mixture was :—

	lb. pe acre
Perennial ryegrass	1
Cocksfoot	1
Timothy	
Late flowering red clover	
Wild white clover	
Trefoil	
Total lb. per acre	3

Since Gilchrist's day there have been numerous modifications of his mixture, including the advocacy of particularised strains in both grasses and clovers. The characteristic special purpose and ultra-simple mixtures of Stapledon in contrast are :—

1. Perennial ryegrass (mixed strains) 14 lb. per acre.
   White clover (mixed strains) 1–3 lb. per acre.
2. Cocksfoot (mixed strains) 14 lb. per acre.
   White clover (mixed strains) 1-3 lb. per acre.
3. Timothy (mixed strains) 14 lb. per acre.
   White clover (mixed strains) 1–3 lb. per acre.

The whole problem of seeds mixtures is very debatable and the emphasis at present is on simplicity involving also considerable reduction in the rate of sowing, always with a view to the special purpose for which any particular ley is designed. The simplest seeds mixture is, of course, one grass *or* one legume as for example when one of the grasses is sown as a pure stand in wide drills spaced two feet apart. This has been the method long used in Denmark and elsewhere for the production of seed crops in the grasses. The sowing of grass in wider spaced drills is now one of the appropriate means for providing winter keep for grazing *in situ*.

An excellent seeds mixture for the general purpose ley which is finding favour is :—

	lb. per acre
Cocksfoot (leafy types)	3
Timothy (leafy types)	5
Meadow fescue (leafy types)	5
White clover (S.100)	3
Total lb. per acre	16

A modern prescription for a lucerne ley is :—

	lb. per acre
Lucerne (an appropriate strain)	15
Cocksfoot (leafy)	2
White clover (S.100)	½
Total lb. per acre	17½

In certain districts cocksfoot tends even at this low seed rate to be somewhat aggressive towards the lucerne, especially after the ley has become fully established and leafy timothy or leafy meadow fescue sown at not more than 4 lb. per acre and preferably only 2 lb. to the acre are then advocated.

Mixtures for one- or two-year leys—The following type mixtures are appropriate :—

		lb. per acre
1.	Ryegrasses (Italian and perennial)	10
	Red clover	10
	Total	20
2.	Red clover	14
	Total	14
3.	Timothy	10
	Red clover	8
	Total	18
4.	Timothy	
	Red clover	
	Alsike clover	
	Total	1
5.	Perennial ryegrass	1
	White clover	
	Total	1
6.	Red clover	
	White clover	
	Alsike clover	
	Ribgrass	
	Trefoil	
	Total	1

This last mixture is commonly used for one year's grazir in districts such as the Wolds of the East Riding of Yorkshir

Lawn Mixtures—

	lb. p acre
Creeping red fescue	
Agrostis tenuis	
Total	

Individual species and strains—The characteristics associated with individual species of the commoner herbage plants and the number of types now available on the British market are given below.

(*a*) **The legumes**—1. WHITE CLOVER—There are a number of distinct strains of white clover available in commerce.

ABERYSTWYTH S.100—A large leaved form suitable for leys under lowland conditions. Where soil fertility is adequate S.100 persists well, particularly where the grazing management is under reasonable control. It is a valuable ingredient even in short duration leys where it should replace the sowing of the non-persistent Dutch white clover. The S.100 type of white clover is appreciably more productive than the typical wild white forms, e.g., Kentish white, and its growing season is also longer. Where, however, the grazing is continuous, as in sheep country and under conditions of low soil fertility, the S.100 forms tend to be eaten out more quickly than the wild white forms.

NEW ZEALAND WHITE CLOVER—The New Zealand government have an arrangement whereby approved stocks of white clover are certified, and it is important to distinguish between these stocks and those coming from New Zealand without a certificate. New Zealand certified white clover in general type approaches S.100, and for all practical purposes can be regarded as roughly the equivalent of S.100, at least in its agronomic behaviour under British conditions.

DUTCH OR COMMON WHITE—This is a short lived type of extremely limited usefulness. In the years prior to 1940 Britain imported the greater part of its white clover seed from Europe and this was almost wholly the common white type, and from a national point of view an undesirable type. Common white, therefore, finds very little usefulness on the ley farm and can now be replaced by the more valuable S.100 and New Zealand certified strains.

LADINO WHITE—Originally of Italian origin this type has in recent years been much used throughout the United States and Canada. It is a large leaved type, very lax in growth, with strongly developed coarse runners. Under American conditions the Ladino type is very useful and comparable with S.100 in Britain. Under British conditions, however, Ladino does not either yield or persist so well as the more valuable S.100 and New Zealand types. Recently *Kersey white clover* has been placed on the commercial market in England, and this seems to have some affinities with the Ladino type and under our conditions is an improvement. The Ladino type generally has one major advantage over S.100, namely, that it starts growth (in the *first* spring after sowing) appreciably earlier than S.100. The latter in this respect has been intermediate between Ladino white which grows very early and English wild white which commences spring growth much later in the season.

WILD WHITE CLOVER—English wild white gained a wide reputation particularly during the period 1910–1940. True wild white clover is an excellent type, dense but rather low in production and with a relatively short growing season. It is, however, persistent under the most severe conditions of grazing. The wild white clover harvested in several English counties holds a sound local reputation, the oldest established strain is known as *Kentish* wild white. Latterly the *Aberystwyth S*.184, a typical English wild white, has been harvested in commercial quantities and has the advantage over most of the English wild whites of being more productive.

2. RED CLOVER—There are two major groups in cultivated red clovers, namely, broad red or double cut cowgrass and late flowering red or single cut cowgrass. The wild red clovers of many old pastures form a separate group, but although these have been tested by plant breeders fairly thoroughly the usual forms of wild red are not to be commended for use in seeds mixtures.

BROAD RED CLOVER—This is a group very widely employed in the commerce of the world. As a type, broad clover starts growth appreciably earlier in the spring than any of the late reds, and the hay crop is ready to cut at the end of May or early June—quite a fortnight sooner than the late reds. There are innumerable local strains of broad red clover emanating not only from various counties in Britain, but from all over the world where intensive cultivation is practised. Innumerable local variations also make it true to say that in general, local strains are better adapted than strains imported from regions climatically different. Thus, in England a large number of agronomic tests have been carried out which show fairly conclusively that the British farmer should be using British broad red. Similarly, the American evidence suggests that within that continent locally adapted strains have advantages over imported seed. Some of these advantages are associated with yielding power, others are related to disease resistance and winter hardiness. It is important for these observations to be recognised, since there is a fairly large volume of international trade in broad red clover. The English buyer of broad red seed should insist on using only the genuine English strains. Where, however, these are not available at any particular time, then the evidence suggests that Canadian broad red and New Zealand broad red are reasonably good substitutes, whereas broad red clover from France, Italy, Southern Europe and the

United States is usually much less useful when grown under British conditions. The converse is probably true in parts of America and in Europe where locally adapted strains are often known to be the best.

LATE FLOWERING RED CLOVER—As with broad red the English buyer should insist on using English late flowering red as being generally superior to seed that may be imported from overseas. This is not always true, for *Montgomery* red clover has been widely grown in New Zealand and seed of this has found its way back to the British market under New Zealand government certificate. Trials have shown that New Zealand grown Montgomery does quite well under British conditions. Similarly, Canadian *Altaswede*, which is a late flowering red clover, does reasonably well in Britain. So also do some of he Swedish and other Scandinavian forms of late flowering ed. As a group the late flowering reds withstand grazing better than even the best of the broad red strains. Among the more useful strains of typical late red can be counted some of he local strains grown in *East Anglia* and again the *Cotswold* type. There are two West Country strains which are well adapted for short grazing leys—these are *Montgomery* red emanating from the Welshpool district in Monmouthshire and *Cornish Marl* which is of somewhat similar type grown locally in the Wadebridge district of Cornwall. These two latter types are distinctly more persistent than the usual run of late flowering reds, and are better able to withstand close grazing n a ley that is down for two or three years. The *Aberystwyth* S.123 late red clover has been bred from selected plants of the Montgomery and Cornish Marl types and is probably the nearest yet under British conditions to simulate a true grazing type of red clover.

3. LUCERNE—This valuable legume has been grown in Britain from the seventeenth century onwards, but until recently the acreage was small and concentrated around the Thames Estuary. Although a typical hay plant, means of employing it in grazing mixtures designed specifically to cater for the dry periods that follow midsummer are being devised. Lucerne is destined to become one of the most valuable legumes for the ley farmer, at least in Southern Britain. The lucerne ley is quickly finding its place in British agriculture and is likely to do so on an increasing scale, particularly when based on cocksfoot, timothy and meadow fescue as the companion grasses.

It is not possible at present to speak of strain or type in the case of lucerne but rather think in terms of country of origin. Most of the seed that comes to Britain is grown either in France or in North America, although small consignments come from

New Zealand and elsewhere. Canadian Grimm, which Britai used almost entirely during the war, thrives well under Britis conditions, so also does the New Zealand Marlboroug lucerne. Certain lots of lucerne, many from Northern Fran and Flanders, also do exceptionally well. The variety *Depui* is of this origin. It may generally be said that lucerne fro warmer climates tends to do less well than lucerne originati from cool climates. Thus, the common lucerne of the southe half of the United States together with those originating South America, South Africa and Australia are less suitab for British conditions than lots originating in Northern Franc New Zealand or Ontario. Seed harvested from old stands lucerne in this country also show up to advantage when so in comparative trials with overseas stocks. Clearly, therefo there is a large field of important work to be done by the pla breeder in the case of lucerne.

4. SAINFOIN—A most valuable legume on calcareous so giving hay and grazing of high quality. The tendency, howe is for lucerne to take the place of sainfoin even in distri where the latter at one time held sway. Sainfoin does seem to be as productive nor, as a ley constituent, so flexi as lucerne. There are two major types of sainfoin, name giant sainfoin which is relatively short lived, and comm sainfoin, a much more persistent form which under go management will hold the ground for five or more yea Sainfoin, like lucerne, is a typical hay plant and also, as in case of lucerne, there is a wide field open for the plant breed The typical sainfoin ley tends to become excessively we after a few years, but this is also true of the pure lucerne l Mixtures of sainfoin with leafy timothy or meadow fes show, therefore, some advantage over pure sainfoin leys beca production is increased and weeds are kept under control.

5. TREFOIL—This is a useful species on thin calcareous s such as the chalkland arable of East England. It is gro extensively in the short duration leys to provide both fod and seed. It is a lime sensitive plant and does not establ well on acid soils. Trefoil (*Medicago lupulina*) is someti confused with yellow suckling clover (*Trifolium minus*). B are annuals but the latter establishes itself abundantly districts of high rainfall and on acid land.

6. ALSIKE CLOVER—The seed of alsike clover has in the mainly come from Eastern Canada where it is employed a constituent of the short term ley. Alsike has limited usefu under British conditions. In the grazed sward it is not productive as say, S.100 white clover, while as a hay crop less productive than either red clover or lucerne. Al however, tolerates adverse soil conditions rather better

either red or white clover, and on the whole is less susceptible to stem rot and other diseases. More research is needed in order to evaluate precisely the place of alsike in seeds mixtures and its various relationships to the other legumes. There are no well recognised strains of alsike that are available in commerce although Scandinavian and other plant breeders have begun to turn their attention to the breeding of improved types of this clover.

7. SUBTERRANEAN CLOVER—Subterranean clover is an annual which has the ability to bury its maturing seed in the surface soil. Its origin is probably the seaboard of Western Europe—it is found growing wild on the littoral from the Mediterranean to as far north as mid-Wales and the Norfolk coast. It seems to have little place in British agriculture for it is surpassed as a grazing plant by white clover and as a hay plant by lucerne, red clover and alsike. At one time it was thought that it might have a place in the drier districts of East Anglia, but recent evidence suggests that lucerne is superior.

(*b*) **The Grasses**—1. COCKSFOOT—The work of plant breeders with cocksfoot has greatly increased its usefulness in Britain. Cocksfoot is most productive under a system of rotational grazing where the plant is allowed long rest periods during which to recover after defoliation. It is a highly productive grass and the leafy strains such as S.143, S.37 and others have made it possible to provide valuable winter grazing from cocksfoot leys. Cocksfoot too is a useful plant in the post-midsummer period when under good management and adequate manuring it produces more green leafage than any other grass commonly used. Apart from the Aberystwyth strains, all of which are leafy and winter green, there is available certified cocksfoot from New Zealand which is also within the leafy group. On the other hand, Danish cocksfoot and Swedish cocksfoot, although providing earlier spring growth than the extreme pasture types, are of less value to us in Britain because of stemminess at midsummer and the marked tendency to winter burn in late autumn Less desirable still under British conditions is the common commercial cocksfoot from North America which shows even less resistance to winter burn than the Scandinavian types, and is also less leafy during the growing period of spring.

2. TIMOTHY—This is among our more valuable grasses but like cocksfoot requires long rest periods between grazings for maximum production. The bulk of the commercial seed comes from Canada and the United States but the type is quite undesirable under British conditions. Scotch grown timothy is essentially of the same growth form as the American but tends to be more leafy and less prone to the rusts and other

diseases when grown in Britain. Much more valuable than these commercial stocks are the bred lines from Aberystwyth and Edinburgh. Corstophine, *Scotia* and *Aberystwyth S*.48 are outstanding lines of timothy which are leafy and very winter green and make possible the use of timothy for winter grazing even as late as January and February. *Aberystwyth S*.50 is a more extreme pasture type, not high yielding, but producing very dense leafage with special ability to remain green and palatable all winter. *Aberystwyth S*.51 is also a valuable leafy type, particularly for providing winter keep.

3. Meadow fescue—A valuable grass which when sown in mixtures with cocksfoot, timothy and the clovers provides the basis for an excellent grazing or hay ley. It gives good aftermath and the bred strains now available are highly winter green. Meadow fescue does not stand close and continuous grazing and therefore fits into a rotational system of farming. Commercial seed largely comes from Denmark and the United States, the latter being usually inferior under our conditions. *Danish meadow fescue* and *Aberystwyth S*.215 have many features in common. They start growth early in the spring, tend to produce too much stem at mid-season but provide good aftermath and remain green well into the autumn and winter. Perhaps the most valuable type of present-day strains of meadow fescue is the *Aberystwyth S*.53 which, although starting growth late in the spring, provides maximum aftermath and under conditions of high fertility makes good autumn growth which retains its greeness and palatability right through the winter.

4. Perennial ryegrass—This grass is still the commonest of all species used in seeds mixtures in Britain, but as time goes on less may be used in relation to other species. Strain is most important in perennial ryegrass. The ordinary commercial types, whether grown in Ireland, Scotland, the United States or New Zealand, are relatively less useful than certain other strains which are available. The usual commercial types start growth early in the spring, produce a lot of unpalatable stem at mid-season, provide very poor aftermath but grow well again in September and October. At every period, however, they are surpassed by one or other of the bred strains. Thus, for early growth the Aberystwyth S.24, New Zealand certified and some of the Danish plant bred material surpass say, Irish commerical. At mid-season this latter strain also tends to run to stem and is not productive again until early autumn. At mid-season especially in late May and June, the Aberystwyth S.23 and S.101 together with the best Kentish old pasture ryegrass, show up more favourably, producing less stem, denser cover of leafage and continuing growth into the early part of the dry season usually experienced

from July onwards. None of the ryegrass strains, however, produce as much aftermath as either cocksfoot or meadow fescue. Neither do the ryegrasses show as much potentiality for " dead of winter " keep as do some of the other species.

5. ITALIAN RYEGRASS—British commerical seed is largely grown in Northern Ireland, although plant bred material is now coming to us from New Zealand, while the Aberystwyth S.22 also provides an improved strain. The New Zealand H.1 may be classed as an Italian ryegrass although it is said to be the result of hybridisation between Italian and perennial ryegrass. The New Zealand H.1 persists about as well under British conditions as ordinary commerical perennial ryegrass. It has a long season of growth and like Italian ryegrass is outstandingly palatable.

6. OTHER GRASSES—Although the foregoing are, for the moment, the major grasses used in Britain, other grasses merit mention. For example, meadow foxtail is little used but this grass has very valuable characteristics such as winter greenness and the ability to start growth very early in the spring. Tall fescue tends to be a coarse and relatively unpalatable grass in summer, but certain strains of tall fescue make abundant growth in autumn, the leafage may remain green well into the winter and growth starts very early in the spring. Winter greenness is also distinctly an attribute associated with certain strains of smooth stalked meadow grass, rough stalked meadow grass, crested dogstail and red fescue. Again in the requirement of hill lands in Britain there is probably a very distinct place for many of these species and also in this latter connection for *Agrostis*. Among the grasses not commonly used in this country but used overseas are such grasses as canary grass (*Phalaris tuberosa*) and Brome grass (*Bromus inermis*) which may have valuable characteristics which could be of use to the British farmer. It would seem, therefore, that as Britain develops the potentialities of her leys and in proportion as the ley is used as the basis of feeding livestock in winter as well as in summer, the whole concept of compounding seeds mixtures and of using a wider variety of species which come into maximum usefulness at specific periods of the year will need to be revised.

(*c*) **The Herbs**—The whole range of herbs known to be palatable may also have a distinct value in ley systems. Not only are many of the grassland herbs palatable but also highly efficient collectors of plant foods, particularly minerals. Some are strikingly winter green and certain strains of Burnet make abundant growth in early autumn and hold their leafage green and nutritious well into the winter. The same may be true of other herbs including yarrow chicory and the parsleys.

Palatability in Herbage Plants—There is much to learn about the relative palatability of the various grasses and clovers in common usage for there is a difference between species and also between different strains within the species. These differences can usually be correlated with two major factors, namely :—

(i) the leafiness of the herbage ;
(ii) the rapidity with which that leaf is growing.

Leafy herbage is generally, though not invariably, more palatable to the grazing animal than stem. Most grass and clover leaves are eaten and highly palatable at one time or another in the year, irrespective of the species to which they belong and irrespective of whether they are classed as "inferior" or "valuable." Certain plants, even in the leafy stage appear distinctly unpalatable ; thistles for example are unpalatable when growing, possibly because of their spiny nature, but are quite palatable in a semi-wilted condition. Docks appear to be extremely unpalatable, although at certain seasons of the year are readily eaten, even when they occur in an otherwise highly palatable herbage. The question of wilted herbage in relation to palatability is one of great interest, for in general growth that is unpalatable when standing is frequently readily eaten 10 to 20 hours after cutting and before it becomes either air dried or mouldy.

Palatability differences between different strains of grasses and clovers vary with the season. Thus S.23 perennial ryegrass is normally less palatable than S.24 perennial ryegrass in March or early April in Britain. In June the position is reversed S.23 being the more palatable being in active growth and leafy, whereas by that time S.24 is largely stem and seed. Stem is usually less palatable than leaf. In early spring on the othe hand, S.24 is in full growth and producing leafy herbage, while S.23 is still dormant. The following statement gives some idea of the average and relative palatability of the leafy materia of the major British species about which evidence exists.

TABLE 45

RELATIVE PALATABILITY OF PRINCIPAL GRASSES AND CLOVER

(LEAFAGE WITH TIMOTHY=100)

Perennial ryegrass	9
Italian ryegrass	9
Cocksfoot	8
Timothy	10
Meadow fescue	9
Tall fescue	7
Tall oatgrass	[illegible]
Meadow foxtail...	[illegible]
Sweet Vernal grass	[illegible]

Crested dogstail	90
Rough stalked meadow grass	95
Smooth stalked meadow grass	80
Red fescue	80
Sheep's fescue	75
Yorkshire fog	30
Agrostis	40
Red clover	100
White clover	100
Alsike clover	100
Lucerne	100

Botanical composition of permanent pastures in Britain—The permanent pastures and meadows of Britain have been classified according to their botanical composition which bears a close resemblance to their agricultural evaluation. The most productive pastures and meadows in the country are normally those in which perennial ryegrass and white clover either predominate or occupy a prominent position. Even in the best permanent pastures however, there is a reasonably wide variety of grasses, legumes and herbs among which a proportion of inferior species is found, the most characteristic of these being *Agrostis*, and Yorkshire fog. As the proportion of these inferior grasses increases at the expense of ryegrass, there is usually a corresponding lowering in the productivity of the pasture or meadow. The pasture therefore, in which the bent grasses predominate to the exclusion of ryegrass and others of superior value is therefore of less agricultural worth than the ryegrass pasture.

Permanent pastures may be classified as follows :—

1. First Grade Ryegrass Pastures in which perennial ryegrass contributes 30 per cent. or more to the sward. Associated with it is a large proportion of wild white clover. This type of grassland is usually found on fertile soils throughout the country, with perhaps concentrations in parts of the Midlands and on the Kent marshes.

2. Second Grade Ryegrass Pasture usually with about 20 per cent. of perennial ryegrass and a corresponding increase in other grasses. These again are found on soils that are of high fertility and with a high standard of pasture management. They are to be found all over the country with perhaps concentrations in such areas as the Cheshire Plain, Somerset Marshes and the western river valleys.

3. Third Grade Ryegrass Pastures. These might alternatively be called *Agrostis*-with-ryegrass pastures. The amount of ryegrass will usually be about 10 per cent. of the sward. There will be an increase in numbers of species and with a definite increase in the amount of *Agrostis*. Many of the

pastures in the chief dairying districts of the country belong to this group, but examples are scattered everywhere, even in the poorest of grassland districts.

4. Agrostis Pastures. This group occupies by far the largest aggregate acreage of any pasture type in Britain, the bent grasses predominating in the sward, while ryegrass is either absent or present only in negligible amounts. Associated with the bent grasses are a wide variety of species, including the herbs as well as such grasses as dogstail, sweet vernal, red fescue and Yorkshire fog. *Agrostis* pasture in its characteristic form may be called the average type of permanent grass in Britain. It occupies something of the order of two-thirds of the total area of permanent grass in lowland England and Wales. There are many modifications of this group, including *Agrostis*-with-rushes-and-sedges and *Agrostis*-with-red fescue the latter being transitional types between typical lowland grassland and the moorland types.

5. Fescue Pastures. These are mainly hill and moorland types in which the dominant grasses are red fescue and sheep' fescue. On the chalklands of Southern England the fescue pastures carry a very wide variety of species, including a numbe of legumes. The typical fescue pasture of the acid soils in the hill country of the West and North is devoid of clover, although birdsfoot trefoil (*Lotus corniculatus*) may often be the only leguminous constituent. Again, associated with the fescue on the downland pastures are such genera as *Avena* (the oa grasses), *Bromus*, *Agrostis* and *Poa* (the meadow grasses). The fescue pastures in the West and North have a much more restricted flora and the associated species consist of sedges rushes, the bent grasses and *Nardus*. The aggregate area in fescue pastures including both hill fescue and downland fescue is very large, probably amounting in England and Wales only to about two million acres or well over one-third of the rough grazings in the country (excluding Scotland).

6. Molinia Moorland. This is largely found in the hil country in districts of high rainfall, particularly in Wales, th North of England and Scotland. There are, however, smal areas of *Molinia* grassland in Southern England, as for example at Bodmin moor, and again occasional patches as on th Bagshot sands in Surrey. The latter are of course relativel unimportant. The total area of *Molinia* in England and Wale is probably a little over one million acres, although much o this area would be classed more correctly as mixed *Molinia* *Nardus* moor. The basic pattern of moorlands, particularly i Wales, is the mosaic of *Molinia* with *Nardus*, but in parts o Scotland almost pure *Molinia* moor occupies fairly larg acreages. Characteristically the *Molinia* moor is dominated b

he one species (*Molinia*) forming large tussocks which make alking across it very difficult and in places even dangerous. Vhere *Molinia* moor is being utilised either for grazing or for ay, then *Molinia* tends to be replaced by *Agrostis*, fescue, *ardus* and sometimes rushes. These plants are usually ssociated with the *Molinia* in the characteristic moorland. ther typical plants are heather, cotton grass, and, occasionally, irdsfoot trefoil.

7. NARDUS MOOR. In Great Britain *Nardus* moor occupies n important position in the hill country, but perhaps is among ne more worthless of our natural hill types. *Nardus* or mat-rass is the dominant species and it is of little grazing value. ssociated with the *Nardus* will be a proportion of sheep's scue, *Agrostis*, rushes, heather, bilberry and *Molinia*. The *ardus* moor usually occupies areas of shallow peat on the eeper hillsides, whereas *Molinia* moor occupies the deeper eat in the valleys and the hollows.

8. HEATHER MOOR. Heather moor holds an important lace in the hill lands of Britain, especially in the eastern half f the Pennine Hills, and on the eastern side of the Cambrian ange in Wales. Heather, therefore, occupies hill areas of wer rainfall than typical *Molinia/Nardus* moor. Heather is ften associated with mixed scrub, fern and almost always ith *Agrostis*, fescue and heath rush (*Juncus squarrosus*). Heather moor must be regarded as a more useful hill type than ther *Molinia* or *Nardus* moorland.

9. COTTON GRASS AND DEER GRASS MOOR. Cotton grass noor is dominated by *Eriophorum* (or drawmoss) and usually ccupies deep and soggy peat lands, either as pockets in other-ise dry hills, or on the mountain plateaux in Scotland, the ennines and in Wales. The flora is a restricted one, the ssociates being deer grass (*Scirpus*), bell heather, *Molinia*, ushes and a number of bogland herbs, including butterwort, og asphodel and sundew. Hill shepherds, particularly in cotland, place high value on drawmoss or cotton grass moors. he cotton grass moor and the deer grass moor are so closely nked that they are included here under the same heading. sually when the proportion of deer grass is greater than the mount of cotton grass, the indications are that the peat is ore shallow or the land slightly less wet. Both cotton grass nd deer grass seem to be largely unpalatable during the greater art of the year, although it is said that both are not only ghly palatable, but invaluable, ingredients of the sheep walk uring the early months of spring.

Hill and marginal lands—In England and Wales there are me 5½ million acres classed as rough grazings and (in 1950) bout 10 million acres in permanent grassland. The rough grazings are largely in hill country, together with some so-call marginal land at lower elevation. The permanent grassla is largely at low elevation, some of it imperceptibly graduati in all material attributes into the marginal land and rou grazings group. There is therefore no clear distinction betwe permanent grass and rough grazing and neither is there a adequate definition of marginal land. Clearly land that m be classed as marginal in one generation may be land that g into rough grazing or else into permanent grass as viewed another generation. Here the term marginal land is used describe what in 1950 is common in the popular mind as margi land, that is, land which can be ploughed or otherwise cultiva and thus its productivity and agricultural usefulness improved. Sometimes such land is marginal because it la drainage, at other times it is marginal because it lies on st slopes, often in high rainfall. Most frequently it is margi land because it is farmed by "marginal farmers" in ot words, if it were well farmed it would no longer be marginal

Clearly before land can be brought into a high state cultivation and productivity, excess water and particul stagnant water must be removed from the soils, i.e., drain is necessary. There is much marginal land, however, wh need not necessarily be drained in order to effect improveme In some cases ploughing and direct reseeding has proved worth on this type of land, while in other cases where fertility is particularly low, the system of pioneer cropp with rape, turnips and Italian ryegrass, all of which are gra *in situ*, has been very useful in building up soil fertility preparing the land for a better class of grass legume ley. Wh marginal land lies in regions of high rainfall as so much c does, then clearly the ley should be the chief, and someti the only crop to be grown. On the other hand, when s land has been brought into usefulness the occasional c crop of potatoes or of oats and other cereals might well taken. The principle of land improvement in relation areas such as those under discussion, i.e., marginal land. fundamentally the same as when dealing with most type land. The basic principle is that the grass/legume ley w adequately farmed, builds up soil condition and increases biological activity of the environment as a whole.

In regard to hill land generally, whether considered marg or not, this general principle holds. Not all areas of hill lands are, however, immediately ploughable. In m cases rocks and boulders prevent the use of the ploug other cultivating implement, whereas steepness of slop often an adequate deterrent to cultivation. In the case of unploughable and uncultivable areas a great deal of experin tation is needed and a new outlook brought to bear upon the problem as a whole. There are at present wide gaps in our knowledge as regards the best utilisation of existing moorland vegetation. It is scarcely known for example how to retain, say, *Molinia* moorland as dominant *Molinia* while at the same time taking off the crop of *Molinia* leaf when that leafage is of high nutritional value. It should be realised that every year such a grass as *Molinia* which occurs in great quantities on many of our hills. produces an annual crop of leafage which is rich in protein and used at the correct stage would provide valuable fodder of reasonably high nutritive value. *Molinia* is one of the most productive grasses on the Welsh and Scottish hills, but seldom is any use made of that productivity, the tendency being to decry *Molinia* as a useless feed for livestock. Chemically although the leafage is high in protein, it is very low in phosphate and perhaps in other minerals. Many hill farmers, however, in both Wales and Scotland harvest their *Molinia* hay fields periodically. Hill cattle live and flourish on well-made *Molinia* hay.

The " weeds " of grassland (see also page 000)—The grass/legume ley is seldom free from so-called " weeds " or miscellaneous herbs, even when land is said to be clean and in high state of fertility. Grassland that has been down for some time always contains a variety of species, some of no apparent usefulness, others acknowledged to be useful ingredients of the sward. On the whole the miscellaneous herbs are leafy and their leafage tends to be richer in minerals that the normal grass and clover species. The high mineral content of many herbs has been used as a basis of the suggestion that herbs play an important part in animal nutrition. Experiments now in progress throughout the country are designed to supply information in this connection.

The manner in which species of various descriptions including he herbs gain entry into the established sward is a matter of onsiderable scientific interest. It is probable that ripe seed s carried on the bodies of grazing animals and birds, and this s one source of seed supply. Another is that stock (again ncluding bird life) eat seeds, and in the case of the ruminant nimal much seed certainly passes into the dung and is deposited n the soil. A very important source of ingress, however, is hrough viable seed that remains alive in the top inches of the oil for prolonged periods. The following statement indicates ow appreciable this is :—

TABLE 46.

POPULATIONS OF VIABLE SEED*

	Per acre
nnual meadow grass	200,000— 4 million
ough stalked meadow grass ...	200,000—10 million

	Per acre
Yorkshire fog	100,000— 1 million
Agrostis spp.	500,000—10 million
Dogstail	Nil —500,000
Docks (*Rumex spp.*)	50,000—500,000
Rush (*Juncus spp.*)	Nil —15 million
Chickweed (*Stellaria spp.*)	50,000—1 million
Daisies (*Bellis spp.*)	Nil —250,000
Catsear (*Hypochoeris spp.*)	Nil —100,000
Hawkweeds (*Hieracium et Crepis spp.*)	Nil —100,000
Buttercup (*Ranunculus spp.*)	200,000—5 million
Hawkbit (*Leontodon spp.*)	Nil —200,000

**After Mrs. S. S. Williams, Grassland Research Station (privately communicated*).

Herbage Seed Production—During the past 30 years greatly improved strains of both grasses and clovers have been made available following upon the work of the plant breeder. Many of these strains are particularly persistent and very leafy in character. Their very leafiness raises a problem in regard to seed production, for some of them are extremely shy seeders Current investigation and practice has shown, however, tha by the employment of certain husbandry methods the quantity of seed per acre grown, from even the most shy-seeding o pasture strains in the grasses, could be appreciably increased The best practice, perhaps, is to grow the grass in wide drills (about 2 ft. apart) to sow without a cover crop and to manure fairly heavily. Clearly, the plant which is maintained consistently at an adequate plane of nutrition contributes more seed than one which is either partially or wholly starved. The principle, therefore, is to maintain a high level of fertility in the soil, ensuring that the supply of lime, phosphates and potash is adequate, and then to provide the crop with supplementary dressings of nitrogen at fairly frequent intervals

If the seed production rows are sown in the spring of one year they should be well established by September of that year During August, a heavy dressing of nitrogen (the equivalen of, say, 3 cwt. per acre of sulphate of ammonia) should be applied to the row crop which should then be rested completely until the winter. The aim should be to grow a big crop o grassy material which, if required, can be consumed during the period November 15th—February 15th by the grazing animal Alternatively, of course, it could be cut and carted indoors The crop then receives a further dressing of nitrogen (abou 2 cwt. per acre sulphate of ammonia) towards the end o February or early in March, and perhaps a similar dressing i April or early May. The seed crop would be cut, in the case of cocksfoot, before the middle of July ; in the case of ryegras in early August and with timothy in late August. Meadow fescue is usually ripe for cutting in early July. After harvesting the crop, the rows should either be grazed closely or cut with a mowing machine carting the stubble away. In some cases the stubble can be burnt with success. The fertilising and management as above is repeated for successive crops of seed. The precise amount of fertiliser depends on the crop to be grown. The indications are that cocksfoot demands a higher level of nitrogen than many of the other grasses. There has been some evidence to suggest that excessive dressing with nitrogen reduces the seed crop in timothy.

When grasses are sown in rows for seed production the seed rate should be of the order of 2–5 lb. per acre. The seed crop in the case of cocksfoot, meadow fescue and ryegrass can be combined, although cocksfoot lends itself to this treatment more than do the others. Timothy is best cut with a binder, put into stooks and later stacked for threshing and hulling. This is particularly true of the pasture types of timothy, some of which present real difficulties in threshing. Yields of clean, marketable seed of the leafy strains of pedigree grasses are as follows :—

	cwt. per acre
Cocksfoot	3–7
Perennial ryegrass ...	3–6
Timothy	3–7
Meadow fescue ...	3–6

(Yields above 10 cwt. cocksfoot seed per acre have been harvested.)

In the case of the legumes the method of seed production is somewhat different. Nitrogen is usually withheld and emphasis is laid on lime, phosphate and more particularly potash.

WHITE CLOVER is usually grown as a broadcast (or close drilled) stand, either alone or with a small seeding of ryegrass or of timothy. A common mixture is 4–6 lb. of perennial ryegrass with 3–5 lb. of white clover. The field is grazed up to the early part of June and then shut up for seed which is harvested in August. The crop when cut has to be carefully handled and should be either cocked or dried on tripods in order to ensure the best seed. The " hay " is threshed and the seed has to be hulled after threshing before being cleaned. Yields are of the order of 100–200 lb. per acre, although with S.100 white clover yields as high as 600 lb. per acre have been obtained.

BROAD RED CLOVER seed is usually harvested as the aftermath crop in the normal one year ley. Hay is taken in late May or early June and the aftermath left for seed which may be cut and threshed by combine, or may be cut loose, placed in a stack after drying and threshed during the winter. Red clover has to be hulled after threshing and then cleaned. LATE RED CLOVER has to be treated somewhat differently. The crop is grazed as with white clover until late May or the first days of June, and is then put up for seed which is ready for cutting in early September. (Broad red clover is usually later to come to harvest where it is grown as aftermath.)

Seed yields in red clover vary tremendously from about ½ cwt. per acre to as much as 7–8 cwt. per acre. The average yield in broad red clover is about 1¼ cwt. per acre and in late flowering red somewhat higher. The yield of clover seed under conditions in Britain is very variable largely because it is so dependent upon the vagaries of the weather. If the soil is very moist then excessive leaf growth is made and pollinating bees find it difficult to get at the flowers. The best clover years are usually dry ones, especially when the months of July and August are dry this ensuring a large population of bees for pollination and also the production of a minimum amount of leafy growth.

Lucerne—The same general principles are applied to the growing of lucerne seed as with red clover. Some lucerne seed is grown in Britain and many growers take the first crop for hay and seed from the aftermath. Others cut an early silage crop and then put up for seed, this latter practice brings forward the date of harvest quite appreciably, though in a wet year the amount of leafage is often excessive and the crop therefore, difficult to handle. Lucerne seed can be combined successfully although the traditional method has been to cut field-dry and stack. The yield of lucerne seed in Britain varies from ½ cwt. to as much as 2 cwt. per acre. In parts of California crops as high as a ton and even 30 cwt. per acre are common These marked differences in yields suggest that the growing of lucerne seed in Britain should not be on any large scale arrangements being made with other parts of the British Empire or elsewhere to grow the seed so long as the strain of lucerne finds approval.

Trefoil—Trefoil seed is grown extensively in Southern England, especially on the chalk soils, and is normally par of the one year ley farming system in these districts. Yields o seed vary from 3 cwt. per acre to about 10 cwt. per acre. Th treatment of the crop is very similar to white and red clove although little or no grazing is done at any time. Trefoil seed has to be thrashed and hulled in the manner of red and whit clover. These same general principles also hold in the case o crimson clover (*Trifolium incarnatum*), sainfoin and indeed, mos other legumes harvested in Britain.

TABLE 47

$$\text{Average Percentage Establishment} = \frac{\text{No. of plants}}{\text{No. seed sown}} \times 100$$

	Percentage Establishment
Perennial ryegrass	40–50
Italian ryegrass	40–50
Cocksfoot	20–30
Timothy	10–15
Meadow fescue	30–40
Tall fescue	30–40
Tall oatgrass	40–50
Meadow foxtail	10–20
Sweet vernal grass	15–20
Crested dogstail	15–20
Rough stalked meadow grass	5–10
Smooth stalked meadow grass	5–10
Red fescue	15–20
Sheep's fescue	15–20
Yorkshire fog	40–50
Agrostis	3–10
Red clover	40–50
White clover	15–25
Alsike clover	20–30
Lucerne	30–40
Sainfoin	30–40
Trefoil	40–50

TABLE 48

LIST OF THE COMMONER INFERIOR NATURAL GRASSES

Botanical Name	English Name	Duration*
Agrostis canina	Velvet Bent	P
Agrostis tenuis	Brown Top	P
Aira (*Deschampsia*) *caespitosa*	Tufted Hair Grass, "Tussock"	P
Aira flexuosa	Wavy Hair Grass ...	P
Alopecurus agrestis ...	Black Grass ...	A
Alopecurus geniculatus ...	Knee-jointed Foxtail	P
Avena pratensis	Perennial Oat ...	P
Avena pubescens	Downy Oat ...	P
Brixa media	Quaking Grass ...	P
Bromus asper	Hairy Brome ...	B
Bromus erectus	Erect Brome... ...	P
Bromus mollis	Soft Brome	B
Bromus sterilis	Sterile Brome ...	A
Holcus lanatus	Yorkshire Fog ...	P
Holcus mollis	Creeping Soft Grass	P
Hordeum murinum ...	Wall Barley Grass ...	A
Hordeum pratense ...	Meadow Barley Grass	P
Lolium temulentum ...	Darnel	A
Molinia coerulea	Molinia, Flying Bent	P
Nardus stricta	Mat Grass, Nardus...	P
Poa annua	Annual Meadow Grass	A
Triticum (*Agropyron*) *repens*	Couch Grass ...	P

* A=Annual ; B=Biennial ; P=Perennial.

TABLE 49

LIST OF GRASSES SOMETIMES GROWN UNDER SPECIAL CONDITIONS

Botanical Name	English Name	Duration*
Agrostis gigantea ...	Red Top	P
Agrostis stolonifera ...	Fiorin, Creeping Bent	P
Aira (Deschampsia) flexuosa	Wavy Hair Grass ...	P
Brachypodium sylvaticum	False Brome Wood Grass	P
Bromus inermis	Hungarian Brome Grass	P
Bromus Schaederi ...	Schaeder's Brome ..	P
Elymus arenarius ..	Upright Sea Lime Grass	P
Festuca gigantea	Giant Bearded Fescue	P
Festuca loliacea	Darnel-leaved Fescue	P
Festuca heterophylla ...	Various-leaved Fescue	P
Festuca tenuifolia ...	Sheep's Fescue ...	A
Festuca rubra	Red Fescue	P
Glyceria aquatica ..	Water Sweet Grass	P
Glyceria distans	Reflexed Sweet Grass	P
Glyceria fluitans	Floating Sweet Grass	P
Milium effusum	Wood Millet Grass	P
Phalaris arundinacea ...	Reed Canary Grass	P
Phalaris tuberosa ...	Toowoomba Grass	P
Phragmitis communis ...	Common Reed ...	P
Poa nemoralis	Wood Meadow Grass	P
Psamma (Ammophila) arenaria	Marram, Sand Reed	P

* A = Annual ; P = Perennial.

TABLE 50

LIST OF THE PRINCIPAL GRASSES, CLOVERS AND HERBS

Botanical name	English name.	Approximate weight of seed per bushel	Approximate number of seeds in 1 lb.	Duration.*
Agrostis tenuis ...	Bent Grass ...	30	5,600,000	P
Alopecurus pratensis	Meadow Foxtail ...	12	490,000	P
Anthroxanthum odoratum ...	Sweet Vernal ...	16	738,000	P
Arrhenatherum avenaceum ...	Tall Oat Grass ...	16	138,000	P
Cynosurus cristatus	Crested Dogstail ...	38	886,000	P
Dactylis glomerata	Cocksfoot ...	22	426,000	P
Festuca duriscula ...	Hard Fescue ...	23	578,000	P
Festuca elatior ...	Tall Fescue ...	24	246,000	P
Festuca ovina ...	Sheep's Fescue ...	28	1,561,000	P
Festuca pratensis ...	Meadow Fescue ...	30	236,000	P
Festuca rubra ...	Red Fescue ...	28	250,000	P
Lolium italicum ...	Italian Ryegrass ...	23	270,000	B
Lolium woldicum ...	Westernwolths Ryegrass ...	20	210,000	A
Lolium perenne ...	Perennial Ryegrass	28	223,000	P
Phleum pratense ...	Timothy	50	1,320,000	P
Poa compressa ...	Canadian Bluegrass ..	30	1,300,000	P
Poa pratensis ...	Smooth-stalked Meadow Grass	26	2,400,000	P
Poa trivialis ...	Rough-stalked Meadow Grass	30	2,235,000	P
Trisetum flavenscens	Golden Oatgrass ...	14	1,400,000	P
Medicago lupulina ...	Trefoil	66	319,000	A
Medicago sativa ...	Lucerne	62	224,000	P
Trifolium hybridum	Alsike Clover ...	66	718,000	P
Trifolium incarnatum	Crimson Clover ..	65	118,000	A
Trifolium medium ...	Zig-zag Clover ...	65	220,000	P
Trifolium minus (or *dubium*) ...	Suckling Clover ...	66	900,000	A
Trifolium pratense ...	Red Clover ...	65	232,000	B
Trifolium procumbens ...	Hop Trefoil ..	66	850,000	A
Trifolium repens ...	White Clover ...	66	732,000	P
Anthyllis vulneraria	Kidney Vetch ..	64	193,000	P
Lotus major .	Greater Birdsfoot Trefoil	64	363,000	P
Lotus corniculatus ...	Birdsfoot Trefoil	66	412,000	P
Carum pretroselinum	Field Parsley	43	230,000	B
Plantago lanceolata	Rib Grass	58	—	P
Poterium sanguisorba	Burnet ...	28	54,000	P
Cichorium intybus ..	Chicory .	36	335,000	P
Achillea millefolium .	Yarrow	36	3,510,000	P

* A—Annual. B—Biennial. P—Perennial.

HAYMAKING

Haymaking—Haymaking simply involves the reduction of the moisture content of the fresh grass from about 80 per cent. to some 15–20 per cent., drying off the unwanted moisture by harnessing sun and wind. At around 15–20 per cent. moisture content, the material can be safely stored in stacks until such time as it is needed for feeding.

Varying effects of Weather—Unfortunately since no control can be exercised over sun and wind, nor on the rain, haymaking is normally a precarious process. During bad weather, the losses in feeding value can be very serious, and even in fine weather appreciable, as shown in the following table of losses in haymaking :—

TABLE 51

Weather	Starch Equivalent per cent.	Protein Equivalent per cent.
Showery	48·4	53·7
Fine	33·0	28·7
Very fine	23·0	17·0
Average	32·0	29·4

These can be regarded, however, as comparatively minor losses, for, should very bad weather persist, it is not unusual to lose the crop completely.

Importance of Time of Cutting—Apart from the weather the final feeding value of the product is influenced by the time of cutting. With increasing age, grasses and clovers decrease in feeding value, and once the flowering stage has been reached, the feeding value rapidly declines, until at the seeding stage it is at a minimum. This is clearly seen in the following figures :—

TABLE 52.

	Crude Protein per cent.	Fibre per cent.
MEADOW FOXTAIL—		
Age one month	17·3	20·1
Age two months	13·1	27·5
Age three months	11·3	28·6
YORKSHIRE FOG—		
Age one month	13·5	22·9
Age two months	9·1	29·3
Age three months	5·4	32·7

Taking Britain as a whole, there is a general tendency to cut hay crops at round the seeding stage, for two very good reasons.

First, the more mature the crop, the less the quantity of cell sap which must be evaporated, and, secondly, the greater the weight of crop to be harvested. Quite apart, however, from the loss in feeding value of the herbage by its lower protein content and higher fibrous nature, if the plants are allowed to reach maturity much shedding of seed occurs, and this adds to the losses.

Work at Aberystwyth has clearly shown also that the feeding value of herbage plants resides in the leaf and not in the stem The case of cocksfoot serves to illustrate this point :—

	Stem	Leaf
COCKSFOOT—	per cent.	per cent.
Crude protein	16·57	24·9
Fibre	26·	23·1

Thus, if the plant is dried to the point of brittleness, as is quite possible when the hot, scorching sun's rays are given full chance to work upon the cut crop, there is a decided danger that the operations of gathering the hay together will break off the leaves, and only the stems will be carted home. Moreover the action of the sun is to bleach the colour, and since the green colouring of plants is associated with carotene, the precursor of vitamin A, this is seriously reduced, whilst vitamin C disappears completely.

Another invisible loss, is due to the effect of heating in the stack. High temperatures reduce the digestibility of the protein in the crop. A slightly browned hay may have lost one-quarter of its feeding value, whilst if the temperature has reached the point where charring has actually taken place, the loss is very much greater.

Finally the composition of the herbage itself has a direct bearing on the value of the final product. The protein content of clover does not fall so rapidly with advancing age as does that of the grasses. Hence, the more clovery the herbage, the better the value of the hay, and the more latitude one has Moreover, weed grasses, such as Yorkshire fog, and bent deteriorate in feeding value more rapidly than perennial rye grass, cocksfoot, or timothy, and, as a result, the higher the proportion of weed grasses present, the lower the potential value of the hay.

The whole position can be summed up by saying that quality in hay is of paramount importance, and to secure this quality means cutting when the crop is in the young and leafy stage drying it as expeditiously as possible, and finally, storing it under cover, thus ensuring an unbleached, unblemished fodder with a pleasant aroma and withal of high feeding value.

Haymaking Methods—Considerable variations in the methods of making hay exist in Britain between county and county and the particular method adopted is largely dictated by weather conditions. In the eastern half of England, where the average rainfall is below 30 inches, full mechanisation is possible, and the very essence of the process is speed. On the western side, and in the northern counties, where rainfall exceeds 30 inches, and where it is unusual to have long spells of dry weather, the essence of the process must be security, and methods have to be adopted which reduce as far as possible the danger of damage by the weather. Basically, of course, the process is identical no matter where hay is made. The crop is cut into swathes which are left to dry on the upper surface before being turned to allow the under surface to dry out. Finally the material is collected together, drying taking place the whole time, until when the moisture is reduced below 20 per cent. it is safe for carting and stacking. Material improvement in the time taken to cure the herbage can be effected by following the mowing machine with a kicker or tedder, or by using a wind-rowing attachment on the mower itself. In this way the swathes are tossed up and lightened, and air circulates throughout the green material. This method, however, can only be adopted in the drier parts of the country, or during spells of settled weather, for the broken swathe is more liable to damage by rain than the untouched swathe. Under normal weather conditions, teasing out the swathe in this way saves one day's fielding. In dry areas, perhaps the greater problem is to avoid mechanical damage to the leaf, for if the crop becomes too dry and brittle, there is a danger that the valuable leaf will be left in the field, and a hay of lower feeding value results.

When the hay is put on tripods, or made into large cocks or pikes this danger is avoided, because it is safe to put the hay together in this fashion whilst the leaf is till pliable. Green hay with 45 per cent. moisture can safely be put on tripods, but a further reduction in moisture to around 30 per cent. is essential before it can be "cocked." Even so, it is clear that this saves a good deal of time compared with having to dry the material to 20 per cent. moisture, or less, for carting direct to the stack. It is the last 10 per cent. moisture which is the most difficult to evaporate, for on a normal sunny day the moisture of cut grass falls from 80 per cent. to as low as 45 per cent. within 4–5 hours of cutting.

There still remains the difficulty of securing the leafy portion of the crop whilst eliminating risk from fermentation in the stack, and here the work at the Midland Agricultural College has indicated that hay can be safely carted at around 30 per cent. moisture content, whilst the stem is supple and the valuable leaf resilient, provided salt, at the rate of 20–40 lb. per ton of crop, is spinkled on the hay as stacking proceeds.

The most recent development in the process having a direct bearing on the quality of the product is that of baling. Hay can be baled at a slightly earlier stage than is considered safe for stacking. In addition, baling saves time and money in cutting out the stack, and most farmers have found the feeding of baled hay to be more economical than when it is fed loose. Two methods of baling are possible—either by sweeping to a stationary baler in the field, or by using a pick-up baler.

Of late, the practice of mow drying, or barn drying, has received considerable attention in Britain. After the initial bulk of moisture has been evaporated from the cut crop by natural means leaving around 45 per cent., the semi-dried hay is carted to the barn, where the making is completed under cover by forcing air through the mass. Hay dried under the barn system is considered to be one grade better than hay made in the field. The chief advantages claimed are less risk of damage through weathering and no risk of complete loss.

The quality in hay may be further improved by the use of nitrogen. Research work at Jealott's Hill and at Leeds University has indicated that when hay is top-dressed with a nitrogenous fertiliser, say 2 cwt. nitro-chalk per acre, as late as 10 to 14 days before cutting the crop, the plant has the capacity for converting the nitrogen into protein, thereby improving the feeding value. Normally, the crude protein of the hay can be increased by 2–3 per cent. in this way, and any nitrogen not utilised by the plant in protein building serves to increase the yield of aftermath. When this practice is adopted in conjunction with earlier cutting, the way is cleared for the production of a much higher quality product.

SILAGE

Ensilage—The process of "ensilage" consists of preserving green forage crops in a succulent condition for use later in the season. "Silage" is the product so obtained and a "silo" is the container in which it is made. The latter may be a round or rectangular above-ground structure of wood, concrete or sheet metal or it may be merely a pit dug in the ground or a stack.

Principles of Silage Making—The process is one of fermentation, the carbohydrates within the plant cells being converted by bacteria carried on the plant material into lactic, acetic and butyric acids. In well-made silage lactic acid is dominant constituting from 0·5 to 2 per cent. of the fresh weight of silage. The formation of this acid must be encouraged to keep the organisms producing butyric acid—which is undesirable—in subjection. Respiration within the mass of material packed into the silo is controlled by compaction or treading the amount necessary varying with the degree of maturity or wetness of the crop and the rate of filling. The temperature should be 80-100°F. and to secure a uniform product, each day's filling should attain this level. The acidity of the mass should be greater than pH 4·5 say pH 4·0 or even less. The only means of controlling the pH is by creating favourable conditions for the rapid production of lactic acid.

Well-made silage is yellowish brown in colour with a pleasantly acid smell of "cheese and pickles." All the plants should retain their leaf formation. The actual feeding value of the silage depends upon the stage of maturity of the crop when cut. Protein in plant tissues is at a maximum at the pre-flowering stage. Thereafter it falls rapidly and is at a minimum when the seed has set. The fall in protein content is not so rapid in leguminous plants as in the grasses and cereals and hence the presence of clover in the grass crop or of tares, peas or beans with a cereal influences the composition of the silage. The ideal is to cut a clovery sward or lucerne when first coming into the bud flower stage or in the case of a cereal-legume mixture, before the ear has shot.

There are three methods of making silage (i) the ordinary (ii) the molasses or indirect acidification and (iii) the acidification method.

The ordinary method—For this method the crop must be cut when past full flower, say the oat kernels cheesy, the tares podded or in the case of grass, when the pollen has blown. At this stage of development the carbohydrates present in the plant supply all the sugary material necessary for the development of lactic acid. Care must be taken when ensiling such mature material to avoid high temperatures giving rise to a brown sweet-smelling product which, though palatable, is of low feeding value much of the protein being rendered indigestible.

Molasses method—Crops cut at an immature stage of development are rich in protein but poor in fermentable carbohydrate and when ensiled, therefore, an easily fermentable carbohydrate such as molasses must be added. Sugar beet pulp, potato flakes and molassed meal preparations have been used to replace molasses. The following amounts of molasses are required :—

Young grass—20 lb. (or 1½ gal.) per ton of crop.
Clover, Lucerne, Sainfoin—30-40 lb. (or 2½ to 3 gal.) per ton of crop.

For moist crops the molasses is dissolved in an lequa volume of water. For dry crops it may be mixed with 2-3 times its volume of water.

Acidification method—The addition of an acid solution direct to the crop to bring the pH level to 3·5 to 4 as rapidly as possible is the basis of the A.I.V. method, the A.I.V. acid used consisting of a mixture of hydrochloric and sulphuric acids with a small amount of organic acid. In America phosphoric acid has been used successfully whilst on the Continent formic acid has been tried. In practice these methods have drawbacks, the concentrated acid being dangerous to handle and needing to be added with some precision to the herbage. Surplus acid may cause serious scouring in the stock.

More recently a machine known as a "Silorator" has been used which has a lacerating action on the plant tissues and in liberating the starchy material within, it is claimed the addition of molasses or acid is unnecessary.

The use of salt has sometimes been advocated. In the concentrations applied it is not a stimulant for bacterial activity nor can it act as a bactericide and hence it is likely that equally good results would be obtained without using salt.

The process of ensilage is wholly preservative and not creative and the value of the final product is determined primarily by the quality of the material ensiled.

Crops for Ensilage—Most herbaceous crops can be made into silage together with by-products from arable farming such a potatoes, sugar beet and mangold tops. Apples also may be made into silage.

Grass—The quality of the silage produced from grass depend upon the age of the material when cut. This is shown by Woodman's figures as follows :—

TABLE 53

Frequency of Cutting	Crude Protein Percentage in Dry Matter
Weekly	24·7
Fortnightly	23·5
Three-weekly	21·1
Monthly	19·7
Five-weekly	19·5

The leaf is moreover richer than the stem in protein. Grass land generously fertilised yields on the average 4 tons of fres grass per cut per acre or three tons of finished silage. Clove lucerne, sainfoin are comparable with young grass in producin high quality silage but yield about 25 per cent. more weight pe acre. The fall in protein with advancing age is not so marked i legumes as in the case of grasses, hence the value of includin them in seeds mixtures for ensiling. These plants all require th addition of molasses when cut at the pre-flowering stage.

Arable Silage Crops—Oats and tares constitute the mo common silage mixture used in this country. In the south th crop is usually sown in the autumn using winter hardy varieties in the north it is more common to rely on spring varieties. Pe may be included in mixtures for spring sowing and beans f autumn-sown crops. Beans should be ploughed in a fortnigh before the cereal components in a mixture. Rye is a very reliable crop but needs to be ensiled before the ear shoots.

The following mixtures are recommended :—

Average Soils	lb. per acre	Light Soils	lb. per acre	Heavy Soils	lb. per acre
Oats	140	Oats	140	Oats	112
Tares or Peas	56	Tares	28	Beans	56
		Peas	28	Tares	56
Rye	112	Rye	112		
Winter vetches	42	Rape	4		
Italian ryegrass	20				

With all cereal-legume mixtures it is useful to sow 10–20 lb. Italian ryegrass to provide keep when the silage crop has been removed.

Cereal-legume mixtures are usually cut when the oats are in the milky stage. Molasses is not required and the silage must be regarded as a medium quality fodder.

Grass and Clover Mixtures—On good land the following mixture has given 8–9 tons of silage per acre per season in three cuts :—

	lb. per acre
Ryegrass H.I. (short rotation)	30
S 100 White Clover	4

as also :—

Italian ryegrass	6
Broad Red Clover	8
White Clover S 100	2
Trefoil	2

On land where lucerne is known to do well the following mixture should be tried :—

	lb. per acre
Cocksfoot	3
Lucerne	20

Maize—Maize is grown extensively in the U.S.A. for ensiling, but in this country it is confined to the drier and warmer districts of the south and south-east. The crop is cut in September when the grain is soft and pasty. No molasses is required. Early maturing varieties like Compton's Early, Eureka, and Early Leeming are now recommended although the older White Horsetooth gives a very good yield. The sowing of maize must be delayed until all danger of frost is over.

Kale—When ensiling in towers the walls must be strengthened by steel bands to withstand the outer pressure which is much greater than with grass or other fodder crops. By far the best method is to use a clamp, the kale which must be chopped, being formed into a large heap without treading or the addition of molasses. The clamp does not require earthing down for a thin layer of mould forms on the outside which forms a perfect seal. Rain should be kept out by covering over with straw. About one-third of the dry matter of the crop is lost in fermentation and drainage, but when yields of 30 tons per acre or more can be obtained the crop is worth growing specifically for silage especially as the protein content is likely to place the silage in the cake-substitute class.

Rape and cabbage can be made into good silage if care is taken to ensure that the mass attains 90° F. Some difficulty may be experienced in chopping well-hearted cabbages.

By-product Silage Crops—Beet tops should be kept free from soil and must be ensiled in a fresh condition. For small quantities a container may be used but for large quantities the pit is by far the best type of silo using the tractor for consolidation. It is advisable to make sure the mass attains 90° F. but no molasses is needed.

Mangold tops can be dealt with in a comparable way. The yield is not so great, lacking the crown of the beet, nor is the feeding value of the final product so good.

Potatoes make excellent silage but are best steamed for the purpose. They can be packed straight from the steamer—after allowing any condensed steam to drain away—in a pit of suitable dimensions. Alternatively a tower silo can be used if suitably strengthened. There is no need to add molasses or watch the temperature and filling can be continuous.

A simpler method for dealing with surplus potatoes in the late spring or early autumn is to place alternate layers of grass (12 in.) and uncooked potatoes (6 in.) in a silo. The heat developed by the grass will partially cook the tubers. If a suitable building exists the potatoes can be steamed *in situ* by leading the steam direct into the container which must of course be airtight.

Pea haulms and pods—Pea haulms should be kept free from soil and ensiled in as fresh condition as possible. Molasses is no required. Pea pods make excellent silage ; no molasses or treading is required but provision must be made for the collection of a considerable quantity of effluent. Over treading must be avoided.

Apple pomace and Brewer's grains can be ensiled successfully Apple pomace is rich in carbohydrate and needs no molasses Fresh brewer's grains mould rapidly and the ensiling must be expeditious.

Above ground silos may need strengthening for both these materials.

Apples—Surplus apples can be ensiled after steaming in the same manner as potatoes.

Handling the Crop—For grass, clover, lucerne and other comparable crops the ordinary mowing machine is quite satisfactory for cutting. When the crop is no longer than eight inches a cutterbar with narrow, close fingers makes a clean job, whilst the fixing of a windrower to the cutterbar, either of the fixed or swinging type, will roll the whole swathe sideways and facilitate its collection with a green crop loader or even by hand. From the swathe or windrow a standard hay-loader fitted with green-crop attachment will pick up the crop cleanly. Forward type or rear action type green-crop loaders are available. With the former type the trailer need not be unhitched from the tractor, which can take the load straight to the silo. A further advantage of this type of loader is that any vehicle can be hitched in front of it, even a horse-drawn cart. Combined cutters and collectors of various types are on the market—these are very efficient but are not so versatile as the usual hay loader type of machine which can be used for sheaves, hay, or combined straw, in addition to grass. For short distance hauls an all-steel sweep or buckrake attached to a tractor by the standard linkage has much to commend it. The binder can be used for cereal-legume mixtures and even for unthinned kale. The most recent introduction is the green-crop harvester which cuts, chops and collects the crop in the field and blows it into a trailer running alongside. The use of this machine reduces the total labour required by about 50 per cent. At the silo, the loads of chopped crop may be fed into the silo with a simple blower or by using the hay elevator. For pit silos, the lorries can be simply and speedily emptied by hand.

For dealing with crops harvested in the long state, cutter-blowers with a capacity of 6–12 tons of green fodder per hour are best for filling tower silos, and have much to commend them for use in pit or clamp silos when the crop is a cereal-legume mixture, or a coarse crop like kale, which will not pack tightly unless chopped.

The system of silage making adopted must be fitted to the farm. There is no one system equally useful for all circumstances. The governing factor in deciding upon a system must be the cost per ton of silage as fed. Systems which on first costs are cheap because the carting costs are low, as say with the buckrake and pit silo in the field, may prove the most expensive in the long run if the silage has to be carted long distances during the winter for feeding.

Types of Silo—A wide variation in size and type of farm sil exists. The simplest and cheapest type is the stack—the mo permanent and expensive the circular tower made of woo concrete or sheet iron. The type of silo selected should fit i with the farm requirements. If surplus fodder is being saved stack is an excellent expedient ; if silage forms part of the liv stock feeding policy a tower silo erected near the cowshed feeding yards may prove cheapest in the long run.

The circular sectional silo is widely used. To obviate was these silos must be made airtight at the joints, they must be fitt with a drain to allow effluent to escape, and a roof must provided to keep out rain water. Brick silos, either circular rectangular are equally good, but the inner walls must be smoo and some reinforcement is essential. Less permanent sil formed from pig netting, steel wire fencing or chespale fenci and lined with sisal paper are quite efficient, but need grea care in erection and filling.

The popular type of silo to-day is the pit dug in the grou which in some cases may be concrete-lined. Clamps wi concrete walls wholly above ground have also many adheren In both cases simplicity of filling allied to the use of the tract for consolidation are the chief advantages. Both types are w suited for use in conjunction with the buckrake. The appro mate capacities of circular silos are given below :—

TABLE 54

Relationship Between Diameter and Capacity of Silos

Height of Silo (feet)	Diameter of Silo (in feet)				
	9	12	15	18	21
5 (1 tier)	5	10	15	22	30 to
6 (2 tiers each 3 ft.) ...	7	12	19	27	37 to
8 (2 tiers each 4 ft.) ...	9	16	25	36	50 to
10 (2 tiers each 5 ft.) ...	10	20	30	44	60 to
12 (3 tiers each 4 ft.) ...	13	24	37	54	75 to
15 (3 tiers each 5 ft.) ...	15	30	47	66	90 to

For pits, a useful size is 14 ft. at the surface, 3 ft. deep a 12 ft. at the base, such a pit holding five tons of green mat for every 3 ft. in length assuming that the silage is built above ground as high as practicable. In practice, this is usua 6 ft. finally settling to 3 ft. above ground level.

The following formula can be used for accurate determination:

$$\text{Length of pit} = \frac{4A \times T}{D}$$

Where A — number of acres to be ensiled
T — tonnage per acre of crop
D — depth of silage in ft. (above and below ground)
and the width of pit is 14 ft.

When stack silage is made, round stacks are preferable to square or oblong ones since better consolidation is then secured. The height of the stack should be not less than 6 ft. after settlement, which means 12 ft. or more during building operations. The diameter should be not less than 12 ft., the walls should be kept vertical and well pulled and, finally, the roof of the stack should be domed to shed rain. Plenty of weight is needed on top to give consolidation to the upper layers of silage. The best covering is undoubtedly not less than a foot of soil well rammed down and kept in position by a rampart of sacks filled with soil placed round the edge of the silo.

Kale can be ensiled by making the simplest of clamps. The clamp is best built on a foundation of straw bales or packed straw, and as the chopped material—chopping being essential—falls from the delivery pipe of the cutter-blower, it is spread evenly over the base and built up into a pyramid. The sides of the clamp must be kept as steep as possible, no treading is needed nor is the addition of molasses necessary. When completed, soiling down is unnecessary, merely a covering of straw to keep out excessive rainfall. A thin skin of mould forms on the surface of the clamp and this forms an effective seal.

The Art of Making Silage—The provision of means for the escape of effluent from a silo is essential no matter what type is used. In the case of permanent silos the use of a sump which can be periodically emptied is advocated, for when the effluent seeps over the stackyard it soon gives rise to very objectional odours. The material should be fed regularly into the silo and well shaken out to obviate air pockets which cause mouldy patches. As filling proceeds, consolidation by treading or using the tractor or even horses is necessary. To secure the correct fermentation, the best guide is to watch that each 3 ft. layer of material filled in the silo is allowed to attain 90° F., or thereabouts, before more is added. When the temperature fails to reach this point, as happens with over-consolidation, too high a moisture content in the herbage, or too rapid filling, a butyric type of fermentation will develop which is undesirable. With inadequate consolidation, very dry material, or too leisurely filling, the temperature is likely to rise above 90° F., and though the silage may be highly palatable, by reason of the temperature—

denoted by dark brown silage—much of the protein may have been rendered indigestible and hence valueless for the animal. Departure from these careful methods of making silage will lead to faults. As to whether it is worth the risk in order to secure more rapid making this is a decision which each individual must make for himself. In circular containers, the centre should always be kept well hearted up to create an outward pressure, and close contact between the crop and the wall of the silo should be secured by treading.

When molasses is used for young succulent crops rich in protein, the solution should be evenly distributed throughout the mass by sprinkling it on say every half load. Some cutter-blowers are fitted with automatic devices for the application of the molasses solution. For dry crops, the quantity of water used can be increased, alternatively it may be reduced when the crops are very succulent or covered with rain-water. The use of a thermometer for taking the temperature regularly is advised. Special instruments for use in silos are available.

When filling is completed, the silo should be sealed effectively to keep out air. The final operations will vary with the type of silo, and fashion in the matter is undergoing many changes. In circular tower silos, as indeed in all types, it is a good plan to top up with waste grass or other material, which should be well consolidated before the final seal of soil is laid on. Some 6–12 in. of soil well rammed into position makes the perfect seal, giving the desired consolidation to the upper layers of silage as well as sealing off from the air. The cost of getting the soil into position is costly of labour and an increasing number of farmers now omit this sealing, merely stripping off the layer of mouldy material which forms on the exposed surface of the silage and contending that this is cheaper than soiling down. Especially is this true of pit silos where a large upper surface is exposed. Where waste material is available for topping up the omission of the soil seal is not serious, but it must be remembered that greater care is then necessary to secure consolidation in the upper layers of the silo.

Causes of Waste in Silos—Side waste—usually consisting of black slimy material varying in thickness from a few inches to as much as a foot along the wall of the silo. The cause is entry of air through the walls of the silo and also from the seepage of rain-water into the silo.

Mouldy Patches—in any part of a silo are caused by air pockets. Failure to shake up the material in the silo, uneven treading or consolidation are the usual causes. Once a silo is opened the silage will soon mould and should be used fresh daily or at most every other day.

Pungent, Evil Smelling Silage—the smell is usually one of ancid butter, is very clinging and is often associated with very vet silage of an olive green colour. This is caused by a butyric ermentation resulting from too low a temperature—less than 0° F.—and is usually brought about by ensiling very immature, vet material and failing to allow the mass to attain 90° F. in ach three foot layer of material added before continuing filling.

TABLE 55

Classification of Silage—

(Grade 1) (High Quality) Cake Substitute (15% and over crude protein)	(Grade 2) (Intermediate Quality) Hay and some Cake, or Hay Substitute (12 to 14·9% crude protein)	(Grade 3) (Low Quality) Hay, Roots or Straw Substitute (Less than 12% crude protein)
Young grass—no grasses in flower lover, lucerne, or sainfoin in bud stage lid-season grass heavily fertilised with nitrogen or grazed late	Grasses at flowering stage Late autumn grass Clover passed full flower Cereal-legume crops cut when cereal is " milky " Marrow stem kale Pea pods	Grasses at seeding stage Stemmy, mature clover Maize Pea haulms and pods Sugar beet tops Potatoes Mangold and turnip tops

Feeding of Silage—Silage can be used for maintenance or roduction requirements of livestock depending upon its uality. No hard and fast rules can be laid down as to the mounts to be fed to the various classes of stock, and farmers sing silage for the first time are urged in their own interests to eek expert help and guidance.

Response of milk cows to silage is very marked and, as it is nportant to maintain the milk supply, cows in milk should have rst call on the silage available and should receive the best that as been made. All dairy farmers experience the difficulty of naintaining yields in March and April, when the cows begin to re of winter rations and the spring grass is still insufficient to stify turning out.

Those who have silage, however, will find that it bridges this ap, and that by its use in the hungry months of the year milk elds can be maintained. By utilising silage to the fullest xtent in the feeding of cows giving up to three gallons of milk, ne short supply of cakes and meals now available can be reserved for the high-yielding cows. An amount of six pounds of good molassed grass silage replaces one pound of balanced dairy ration.

Silage is also a valuable food for fattening cattle, and high quality silage replaces the cake normally fed to this class of animal. To feed a large quantity of this type of silage, however, may be wasteful by providing more protein than the animal requires. Thus the intermediate quality silage may be more useful to replace hay, straw or roots, for fattening cattle.

Recent work in Northern Ireland has shown that good grass silage can be fed alone as a fattening ration for bullocks. Up to 126 lb. per head per day was fed for 10 weeks during which period the average liveweight increase per day was 2·8 lb., the killing out percentage being 60.

As a general rule, however, dairy and fattening stock will receive up to 35 to 45 lb. per head per day, along with other foods.

Store cattle are likely to winter well on a ration of 20 to 30 lb. of silage (Grade 2 or 3) in addition to hay, and calves should have it introduced into the ration at an early age to replace part of the roots and meal.

It is not generally realised how useful silage is for ewes in lamb and for fattening wethers. It should be introduced to them gradually by feeding about one lb. per head per day, preferably of good quality silage made from short grass. Results over a number of years show that a ration of 10 to 12 lb. silage with 6 lb. good hay and one lb. crushed oats is likely to give a liveweight gain of two to three lb. per sheep per week. Compared with feeding roots silage will show appreciably lower costs of production and in labour of feeding.

There is no reason why the sole diet should not be good grass silage and in one recorded case in Northumberland over a period of two years feeding lambs weighing 124 lb. liveweight had grass silage alone from December until sold fat (67–69 lb. deadweight) some five to six weeks later.

Ewes do especially well when silage forms at least part of the diet. They lamb easily, milk well and are markedly healthier under adverse weather conditions whilst their lambs are noticeably superior to those running with ewes receiving no silage. In one particular trial in Yorkshire ewes which received 5 lb. of good grass silage per head per day from three weeks prior to lambing until weaning time showed 10 per cent. less mortality amongst the lambs which averaged 5 lb. per head heavier when weaned compared with lambs from comparable ewes which did not, however, receive any silage during the comparable period. With all sheep care must be taken not to feed any doubtful silage. It can be thrown out on to grass or given in racks, but it must be protected from wet or it becomes slimy and refused by the sheep and hence racks are to be preferred.

Silage is much too bulky a feed to play any considerable part in the feeding of pigs or horses, as both classes of stock have comparatively small digestive organs. Pigs can receive up to 2 lb. daily as a tonic and supplier of vitamins, lack of which is often responsible for many pigs failing to thrive. Empty sows can receive as much as 15 lb. and this replaces 3 lb. of pig meal. The silage fed to pigs will largely be of the by-product type. Potato silage is particularly useful for pigs, replacing steamed potatoes.

Although silage is seldom fed to horses, brood mares benefit from a few pounds daily of molassed grass silage during the winter, whilst up to 25 lb. per day can be fed to working horses without fear of ill effects.

At a time when concentrated foods are in very limited quantity the introduction of silage into poultry rations deserves attention. Little information is available as to its use in this country, but American and Continental experience is fairly extensive and has shown that when the silage is chopped and mixed with meal to a crumb-like consistency, up to two oz. per bird per day can be consumed, and the quantity of laying meal required reduced by as much as 25 per cent. Usually, when small quantities of silage for poultry are required it can best be made in barrels holding about three cwt. Lawn clippings are ideal for this purpose. Steamed potato silage is equally valuable.

GRASS DRYING

Artificial Drying—When grass, clover or lucerne is dried by artificial means there is little loss in feeding value and the product is rich in protein. The dried material is easily stored, transported and simple to ration and, in this respect, superior to silage. For pigs and poultry it is the only convenient protein-rich concentrate which can be obtained from grassland. Dried grass is a valuable food because it contains a large range of vitamins, easily digested minerals and the full range of the proteins required by farm animals. It makes other foods go further by supplementing the insufficient range of proteins available in cereals and seed crops.

High quality grass for drying is grown by fertilising good permanent or temporary leys with nitrogen, phosphates and potash, e.g., 3 cwt. of superphosphate, 1 cwt. of muriate of potash and 6–12 cwt. of ammonium sulphate or nitro-chalk per acre. The nitrogen can be applied in the spring at 4 cwt. per acre and the rest at intervals later in the season. Three, four or five cuts of grass are made during the summer. The approximate yield obtainable and the quality of the dried grass is given in the following table, the crude protein content being the average of all the cuts made during the summer.

TABLE 56

Total weight of nitro-chalk applied per acre.	Crude protein in dried grass Average of all cuts.	Total weight of dried grass ; all cuts from 1 acre.
cwt.	per cent.	cwt.
0	11	35
6	16	50
12	18	60
15	20	70

Cutting and Collecting—The grass is usually cut with an ordinary hay mower and first wilted in the field for one to two days to remove some of the water content. Less drying is then necessary at the drying plant. The swathe is either picked up by hand-loading into carts or trailers or with a buck rake on a tractor or with a green crop loader. A Cutlift cuts and delivers the grass into a trailer which carries it in the unwilted state to the drier.

Lucerne does not require nitrogenous fertilisers but if lucerne-grass mixtures are grown nitrogenous fertilisers must be applied or the protein content of some of the cuts will be low.

Driers—In all driers hot air is used to remove water from the grass, the air being heated by burning coke or oil although coal is sometimes used. In the tray drier the wet grass is spread upon a perforated tray through which air from 100°–300° F. is forced by means of a fan. In conveyor driers the grass is carried continuously along one or more conveyors whilst hot air is forced through the grass to dry it. In drum driers chopped grass is fed into a horizontal rotating drum into the same end of which hot air is blown. The grass and the hot air travel in the same direction and the flow of each is regulated so that dry but not scorched grass passes out of the other end of the drum. In pneumatic driers the grass is passed into a tube along which the heated air is moving at a high velocity and the grass is dried as it is carried along by the stream of air. In drum and pneumatic driers the temperature of the gas is usually 500° F. to 1,500° F. Some driers are combinations of several of these types.

Water content of grass—As the grass stands in the field the water content varies with age and the weather. On an average day this may be a little over 80 per cent. in the morning but less in the afternoon. The table below shows the weight of wet grass containing 1 lb. of dry matter and the number of pounds of water to be evaporated to make 1 lb. of dried grass for grass of different water contents :—

TABLE 57

Percentage water in grass	90	85	80	75	70	67	60	50
Weight of grass containing 1 lb. of dry matter	10	6½	5	4	3⅓	3	2½	2
No. of lb. of water to be evaporated to make 1 lb. dried grass	9	5½	4	3	2⅓	2	1½	1

The drier is usually run to full capacity and evaporates a fixed amount of water per hour whatever the water content of the grass being dried. The output of the drier varies with the amount of water in the grass and this affects the cost of fuel and labour per ton of dried grass produced as shown in Table 58. It is assumed that the drier evaporates 10 cwt. of water per hour and consumes 1·8 cwt. of coke or 16 gallons of gas oil per hour.

TABLE 58

Percentage water in grass to drier... ...		67	70	75	80
Weight of water evaporated, per hour ...		10 cwt.	10 cwt.	10 cwt.	10 cwt.
Weight of crop carted to drier, per hour ..		15 ,,	14·3 ,,	13·3 ,,	12·5 ,,
Weight of dried grass made, per hour ..		5 ,,	4·3 ,,	3·3 ,,	2·5 ,,
Fuel consumed per hour	Coke	1·8 ,,	1·8 ,,	1·8 ,,	1·8 ,,
	or Oil	16 gal.	16 gal.	16 gal.	16 gal.
Fuel consumed per *ton* dried grass	Coke	7·2 cwt.	8·4 cwt.	10·9 cwt.	14·4 cwt.
	or Oil	64 gal.	75 gal.	97 gal.	128 gal.

TABLE 58—*continued*

	s.	d.	s.	d.	s.	d.	s.	d.
Cost of fuel per *ton* dried grass if coke is £5 per ton	36	0	42	0	54	6	72	0
If gas oil is 1s. per gallon	64	0	75	0	97	0	128	0
Cost of labour per ton of dried grass if cost is 10s. per hour ...	40	0	46	0	60	0	80	0

Storage of Dried Grass—Dried grass does not pack like hay, being very springy. When trodden down it only packs to about 6 lb. per cubic foot. It can be made into chaff one to two inches long, and trodden down in chaff rooms when it packs to about 12 lb. per cubic foot. It may be made into bales weighing 80 to 90 lb. with an ordinary straw baler or a small baler may be used for making bales 30 to 40 lb. The density in bales varies from 12 to 20 lb. per cubic foot, but bales of about 12 to 14 lb. per cubic foot require less power and are quite satisfactory. Dried lucerne is too brittle to make into bales. Grass or lucerne may be ground to a meal in a hammer mill and kept in bags, the density of which is about 24 lb. per cubic foot. Meal is best for storage and transport and for feeding to poultry or pigs, but bales are the most convenient form for feeding to cattle. If dried grass, packed in paper bags, is stacked about 6 feet high one ton occupies two square yards of floor space.

Dried Grass Analyses—The feeding value of dried grass or lucerne is related to the crude protein content as shown in Table 59. Driers should have their product analysed for crude protein weekly by the National Agricultural Advisory Service or by Agricultural Analysts. Sampling should be done carefully—a handful of meal being taken from every fifth bag and put into a closed box. At the end of the week this must be well mixed and about half a pound sent for analysis. Bales should be sampled by boring a hole through about one bale in ten—mixing the samples obtained in a closed box and then carefully making an average sample from the contents of the box. It is very difficult to get an average sample from the grass before it is baled for the leaves, which are brittle, break up and too little leaf matter is therefore included in the sample which is then too low in crude protein.

The fibre content of dried grass varies from 20-30 per cent. Since cattle and other ruminants digest a large proportion of the fibre the content of fibre is of little moment for them. But for feeding pigs and especially poultry it is advisable to select dried grass which is low in fibre. High protein dried lucerne often contains only 15–18 per cent. of fibre. This is particularly valuable for poultry mashes. Dried cabbages, kale leaf and similar crops often have low fibre contents.

The beta carotene content of dried grass, which is a measure of the vitamin A potency, usually varies between 200 and 400 milligrams per kilo and for lucerne between 100 and 300 milligrams. When dried grass or lucerne is included in a ration to provide starch equivalent and protein the animal receives all the beta carotene required if the carotene content is over 80 milligrams per kilo. Although dried grass loses beta carotene gradually on storage any sample which contained more than 100 milligrams per kilo at the time of manufacture will still provide all the carotene that an animal requires. On the other hand, if small quantities of dried grass are added to a ration for the sole purpose of supplying vitamin A a high carotene sample is preferred because less of it will be required.

The following are typical analyses of dried grass and lucerne :—

TABLE 59

Specimen analyses of dried grass and lucerne.

DRIED GRASS.

	Per cent. of the dry matter.			
Crude Protein	10·86	14·55	16·36	19·09
Fibre	28·2	25·38	26·00	24·80
Beta Carotene milligrams per kilo	Varies from 200 to 400			

DRIED LUCERNE.

Crude Protein ...	16·43	18·2	20·62	22·56	23·93
Fibre	26·35	23·4	17·45	15·45	15·65
Beta Carotene milligrams per kilo ...	150	210	205	210	275

Under the Ministry of Agriculture scheme for the grading nd marking of dried green crops the grade is determined by he per cent. of crude protein when the moisture content is 10 per cent. The feeding values used for dried grass and ucerne in the following tables are, therefore, those for grass r lucerne containing 10 per cent. moisture.

CATTLE—Feeding—Dried Grass—Table 60 shows the elationship between the crude protein content of dried grass nd its feeding value. It also shows the weight of dried grass f different qualities which is on an average required by cattle ; ndividual cattle will require a little more or a little less from day to day.

TABLE 60

Weight (lb.) of dried grass containing 10 per cent. moisture to be fed to cattle.

Crude Protein in dried grass per cent.	10–11	12–13	14–15	16–17	18
(*a*) Starch Equivalent ...	51	52	53	54	55
Protein Equivalent ...	5·5	7·5	9·5	11·3	12·
	lb.	lb.	lb.	lb.	lb.
(*b*) Daily ration for young stock—					
Weight of animal 2 cwt.	—	—	—	6	6
4 „	—	—	8½	8	8
6 „	—	—	10½	10½	10
8 „	—	13	13	12½	12
(*c*) Daily ration for fattening cattle for 1½ to 2 lb. live weight increase per day—					
Weight of animal 6 cwt.	—	18	18	17	17
7 „	20	20	19	19	18
8 „	21	21	20	20	20
9 „	23	22	22	21	21
10 „	24	23	23	22	22
Plus oat or barley straw.					
(*d*) SHORTHORN OR FRIESIAN COWS—					
Maintenance ...	14½	14	14	13½	13
„ and 1 gallon	—	19	18½	18	18
„ „ 2 „	—	24	23½	23	22
„ „ 3 „	—	—	28	27½	27
„ „ 4 „	—	—	33	32	31
AYRSHIRE COWS—					
Maintenance	12	11½	11½	11	11
„ and 1 gallon	—	16½	16	16	15
„ „ 2 „	—	21	21	20½	20
„ „ 3 „	—	—	25½	25	24
„ „ 4 „	—	—	30	29½	29

GUERNSEY COWS—					
Maintenance	12	11½	11½	11	11
„ and 1 gallon	—	—	—	16½	16½
„ „ 2 „	—	—	22½	22	22
„ „ 3 „	—	—	28½	27½	27
„ „ 4 „	—	—	34	33½	33
JERSEY COWS—					
Maintenance	9½	9	9	8½	8½
„ and 1 gallon	—	15½	15	14½	14
„ „ 2 „	—	—	21½	21	20½
„ „ 3 „	—	—	28	27	26½
„ „ 4 „	—	—	34	33	32½

NOTES ON TABLE 60

(*a*) The starch equivalent and protein equivalent corresponding to various crude protein contents.

(*b*) The daily ration for young cattle necessary for maintenance and for an increase in live weight for normal growth of about 1 lb. per day. Calves will start eating dried grass when three weeks old, and at 2 to 3 months they will eat about 4 lb. per day.

(*c*) The daily ration for fattening cattle to produce about 2 lb. live weight increase per day. The cattle should have access to oat or barley straw so that they can satisfy their appetites after they have consumed the dried grass.

(*d*) The daily ration for cows of various breeds for maintenance and a yield of 1, 2, 3 or 4 gallons of milk.

The following table shows the weight of dried grass to be fed as a production ration for 1 gallon of milk when the cow has received some other food for its daily maintenance :—

TABLE 61

Weight of dried grass to be fed for 1 gallon milk.

Crude Protein in dried grass, per cent.	15	16	17	18
Breed of cow—	lb.	lb.	lb.	lb.
SHORTHORN OR FRIESIAN ...	5	4½	4½	4½
AYRSHIRE	5	4½	4½	4½
GUERNSEY	6	5½	5½	5½
JERSEY	6¾	6¼	6	6
GOATS	6¾	6¼	6	6

Where no figure is given in the above tables it is because dried grass of that quality is too low in protein to be an economical food.

DRIED LUCERNE—Dried lucerne contains more protein equivalent and less starch equivalent than dried grass so that it requires mixing with a starchy food such as oats, barley, or maize in making up a milk production ration for cows. The amount of dried lucerne to be mixed with a starchy food to make a balanced milk production ration depends upon the quality of the dried lucerne. Table 62 gives the starch equivalent and the protein equivalent of dried lucerne from 16–24 per cent. crude protein content and the weight of each quality to be mixed with given weights of some common starchy foods.

TABLE 62

Table for mixing lucerne meal with some starchy foods, and the amount of the mixture to be fed for 1 gallon of milk in each case.

Crude Protein in lucerne meal containing 10 per cent. moisture, per cent.	16	18	20	22	24
Starch Equivalent, per cent. ...	43	45	47	49	51
Protein Equivalent, per cent.	11	13	14½	16	18
lb. of lucerne meal to be mixed with a starchy food ...	90	52	40	31	26

lb. of starchy food to be mixed with lucerne meal.		Weight of mixture in lb. to be fed for 1 gallon of milk to Shorthorn, Friesian or Ayrshire cows.				
	lb.					
Barley	30	5½	4½	4½	4¼	4¼
or Linseed	40	4	3¼	3	2¾	2¾
or Maize	25	5½	4¼	4¼	4	4
or Maize Germ Meal	30	5	4	4	3¾	3¾
or Oats	45	5½	4½	4½	4½	4¼
or Rye	40	5¼	4½	4¼	4¼	4
or Sugar Beet pulp	30	6	4¾	4¾	4¾	4½
or Wheat	40	5¼	4½	4¼	4¼	4

Guernsey cows require one-fifth more than the above quantities and Jersey cows one-third more.

EXAMPLE—40 lb. lucerne meal (20 per cent. crude protein) and 45 lb. of oats are mixed to make a milk production ration and 4½ lb. are fed for each gallon.

PIGS—Dried grass or lucerne can replace the weatings in a ration for in-pig sows, suckling sows and fattening pigs. The amount fed can be 30 per cent. of the total food. On account of its vitamins and minerals it enables sows to rear large litters.

POULTRY—All poultry mashes should contain 7–10 per cent. of high protein dried grass or lucerne meal. This is particularly important in the case of birds kept in batteries for it provides vitamin A, vitamin B, some useful minerals and proteins, and ensures that the yolks of the eggs will be of a good colour and not white.

FRUIT, VEGETABLES, GLASSHOUSE CROPS

FRUIT GROWING

Apples (dessert) in Order of Maturing

Early (Aug.–Sept.)—*Beauty of Bath, Laxton's Epicure.

Mid-Season (Sept.–Oct.)—*Worcester Pearmain, Ellison's Orange, *James Grieve, Laxton's Fortune, Lord Lambourne.

Late (Oct.–Nov.)—*Cox's Orange Pippin, *Blenheim Orange, Allington Pippin, Laxton's Superb, Sunset.

Very Late (Nov.–Jan.)—Winston, Wagener, Sturmer Pippin.

Apples (cooking) Order of Maturing

Early (July–Aug.)—Emneth Early (syn. Early Victoria).

Mid-Season (Aug.–Oct.)—Grenadier, Lord Derby.

Late (Oct.–Jan.)—*Bramley's Seedling, *Lane's Prince Albert, Monarch.

Very Late (Dec.–Mar.)—*Newton Wonder, *Crawley Beauty, Edward VII.

NOTE—Some apples are self-incompatible; some only partly self-compatible: others have bad pollen. Those marked above* should always be planted with suitable pollinating varieties. All apples are better for cross-pollination.

Pears (in Order of Maturing)

Early (Aug.–Sept.)—Laxton's Superb, William's Bon Chrêtien.

Mid-Season (Oct.–Nov.)—Dr. Jules Guyot, Beurré D'Amanlis, Fertility, Emile D'Heyst, Conference.

Late (November)—Durondeau, Beurré Hardy, Doyenné du Comice.

NOTE—Most varieties of pears require cross-pollination to nsure adequate crops and should be planted with suitable reciprocal pollinators.

Plums (in Order of Maturing)

End July onwards—*Early Laxton, *Rivers's Early Prolific, Cherry Plum (Myrobalan), Czar, *Cambridge Gage, Victoria, Denniston's Superb, Oullins Golden Gage, Belle de Louvain, Jefferson, *Bryanston Gage, *Pond's Seedling, Giant Prune, Warwickshire Drooper, *Kirke's Blue, Marjorie's Seedling, Blaisdon Red, Kentish Bush, Monarch, *President.

NOTE—Some plums are self-incompatible and others only partly self-compatible. Those marked above * should always be planted with suitable pollinating varieties.

Cherries (in Order of Maturing)

Early—May Duke (June), Early Amber, Early Rivers, Frogmore, Knight's Early Black, Nutberry Black, Governor Wood.

Mid Season—Amber Heart, Roundel Heart, Waterloo.

Late—Emperor Francis, Napoleon, Gaucher, Noble, Bradbourne Black, Noir De Guben, Turkey Heart, Geant D'Hedelfingen, Florence, Ohio Beauty (August).

NOTE—All sweet cherries are self-incompatible. Also cross-incompatibility exists. Each of the above varieties must therefore be grown with a *suitable* pollinating variety *which is reciprocal.*

Blackcurrants (in Order of Maturing)

Boskoop Giant, Mendip Cross, Davison's Eight, Goliath, French Black (Seabrook's Black), Wellington XXX, Westwick Triumph, Baldwin, Cotswold Cross, Westwick Choice, Daniel's September.

NOTE—Blackcurrants are attacked by the "reversion" virus; healthy stock only should be planted. Officially certified stocks are available in quantity.

Red Currants (in Order of Maturing)

Earliest of Fourlands, Laxton's No. 1, Fay's Prolific, Laxton's Perfection, Wilson's Longbunch.

Gooseberries (in Order of Maturing)

May Duke, Keepsake, Careless, Lancashire Lad, Whinham's Industry, White Lion, Early Sulphur, Leveller.

NOTE—The last two varieties are especially suitable for dessert fruit.

Raspberries

Lloyd George, Malling Enterprise, Malling Landmark, Malling Promise, Newburgh, Norfolk Giant, St. Walfried.

NOTE—Raspberries are attacked by virus diseases; healthy stock only should be planted. Officially certified stocks are available.

Rootstocks for Fruit Trees

Rootstock affects both the *size* of tree and the crop-yield phase. Stock-scion incompatibility exists with plums and pears and is overcome (in some instances) by double-working (pears). With plums, a suitable single rootstock should be used.

Apples—M.VIII—French Paradise, dwarfing, very early fruiting. M.IX—Jaune de Metz, dwarfing, very early fruiting. M.VII—Semi-dwarfing, early fruiting. M.I—English Broadleaf, semi-vigorous, fairly early fruiting. M.II—Doucin, semi-vigorous, fairly early fruiting. M.V—Doucin Amelioré, semi-vigorous, fairly early fruiting. M.VI—Nonsuch, semi-vigorous, fairly early fruiting. M.IV—Holstein Doucin, semi-vigorous, fairly early fruiting. M.XIII—Vigorous, fruiting delayed.

M.XII—Vigorous, fruiting delayed. M.XVI—Ketziner Ideal, very vigorous, fruiting much delayed. M.Crab C.—Very vigorous, fruiting much delayed.

PEARS--Seedling Pear—Large vigorous trees, cropping delayed. Quince A—Moderately vigorous trees, cropping early. Quince B—Moderately vigorous trees, cropping early. Quince C—Dwarfing, cropping very early.

NOTE—Certain varieties of pears are stock-scion incompatible; these should be *double-worked*, using an intermediate variety as a stock-scion compatible union.

PLUMS—Myrobalan B—Gives large and vigorous trees, fruiting delayed, not suitable for gage plums. Brompton—Gives large healthy trees. Marianna—Medium to large trees, not suitable for *Czar*, *President*, *Oullins Golden Gage* and damsons. Common Mussel—Medium to small trees. Pershore—Small trees. Common Plum—Medium trees, not suitable for *Czar*, *President* and damsons. St. Julien A—Medium trees. Damas C—Medium to strong trees.

NOTE—Certain rootstocks are stock-scion incompatible, e.g. *Czar* on Common Plum. Certain local plums, e.g., *Pershore*, are commonly grown on their own roots.

CHERRIES (Sweet and Acid)—Sweet Cherry (Mazzard, Gean, Gaskin), M.12/1. Large trees of sweet cherry. Acid cherry small to medium trees.

Peaches and Nectarines

Peach Seedlings—Large vigorous trees. Plum rootstocks—Brompton, Damas C, Common Mussel—Large to medium trees. St. Julian A—Medium to small trees.

Apricots

Plum rootstocks, Brompton and Common Mussel for large trees.

Planting Tables for various Fruits

TREE FRUITS—(Apples, Pears, Plums, Cherries)

Distance in feet.	*No. of trees per acre.*			
7×2	3,000	cordons (apples)		
7×2½	2,500	,,	,,	
6×3	2,300	dwarf pyramids (apples)		
7×3	2,074	,,	,,	,,
8×4	1,360	,,	,,	,,
9×9	537	small bushes (apples)		
10×10	435	,,	,,	,,
11×11	360	,,	,,	,,
12×12	302	,,	,,	,,
13×13	257	medium bushes (apples, pears, plums)		
14×14	222	,,	,,	,,
15×15	193	,,	,,	,,

16×16	170	medium bushes (apples, pears, plums)
17×17	150	,, ,, ,,
18×18	134	,, ,, ,,
20×20	109	large bushes and half standards (apples, pears, plums)
22×22	90	,, ,, ,,
24×24	75	,, ,, ,,
28×28	56	standards (apples, cherries)
30×30	48	,, ,, ,,
35×35	35	,, ,, ,,
40×40	27	,, ,, ,,

NOTE—The above figures are for square planting. For hexagonal or triangular planting the number given for square planting should be divided by 0·866. *Example* : 10 ft. hexagonal:-

$$\frac{4{,}840\times 9}{10\times 10\times 0{\cdot}866} = 503$$

Bush Fruits (Currants and gooseberries)

Distance in feet.	*No. of bushes per acre.*
10 ×3	1,452
8 ×4	1,361
4½×4½	2,151
5 ×5	1,742
6 ×6	1,210
7 ×7	888
8 ×8	680

Raspberries

Distance.	*No. of canes per acre.*
5 ft.×18 in.	5,804
6 ft.×18 in.	4,600
7 ft.×18 in.	4,148

Strawberries

Distance.	*No. of Plants per acre.*
2 ft.×18 in.	14,520
2½ ft.×18 in.	11,616
3 ft.×18 in.	9,680

Bushel and Sieve Weights of Fruits

Apples—bushel = 40 lb.
Pears—bushel = 48 lb.
Cherries—sieve = 48 lb.
Cherries—half-sieve = 24 lb.
Plums—sieve = 56 lb.
Plums—half-sieve = 28 lb.

Planting

May be done between the middle of October and end of February, but November is the best month. A hole, 3 ft. wide and 1 ft. deep, should be dug for each tree, and the subsoil broken up, and some time before planting, so as to aerate the soil. A stake is driven in, six in. of soil replaced, the young tree tied to the stake, the roots spread evenly, and the soil filled in, and trodden firmly down. The surface should be kept cultivated for several years afterwards, as grass is very harmful to young trees. Not more than six per tree of the larger fruits—such as apples—should be allowed to ripen during the first season.

Some varieties are self-incompatible and some are good pollinators. At least one tree of good pollinating power must be planted to every ten.

Fruit trees respond best to potash manures but some nitrogen is also required: stable manure tends to promote growth of tree. A suitable dressing of potash is two to four cwt. sulphate of potash per acre. Nitrogen should be applied regularly at the rate of three to four cwt. sulphate of ammonia or five cwt. nitrate of lime (nitro chalk) per acre per annum.

Control of Fruit Pests by Grease Banding

Strips of grease-proof paper, eight in. wide, tied round stems at over three feet from ground, and grease compound smeared on these. With older trees the grease can be placed direct on the bark of the stem. Best time is in beginning of October. Object is to check the upward passage of the wingless females of the winter moths.

Control of Fruit Pests and Diseases by Spraying

Materials—Tar oil, petroleum oil, DNOC (dinitro-ortho-cresol), DDT, derris, nicotine, HETP (hexaethyl-tetra-phosphate), lime-sulphur, arsenate of lead, Bordeaux mixture, flowers of sulphur, copper preparations. Most of these materials are manufactured as proprietaries. Follow makers' instructions. The diluent with all liquid sprays is water plus a suitable spreading agent (spreader).

Apples

Prevalent pests and diseases—Aphids, sucker, capsid, blossom weevil, sawfly, codling moth, red spider mite, caterpillars (various), scab, blossom wilt, mildew.

Spraying Programme of General suitability—

Time of spraying.	Materials.	Pests and diseases controlled.
Pre-blossom, dormant bud. Mid. Feb.—Mid-March.	DNOC 5%. If required add DDT 0·1%	Eggs of aphids, sucker, red spider mite by DNOC. Blossom wilt. Blossom weevil by DDT.
Pre-blossom, green bud. Mid-April.	Lime-sulphur 2½%, add DDT 0·1%.	Scab, capsid, caterpillars.
Pre-blossom, pink bud. Late April.	Lime-sulphur 2%.	Scab.
Post-blossom, petal fall. Early May-Mid-May.	Lime-sulphur 1%, add nicotine 8 fluid oz. per 100 gal.	Scab. Sawfly.
Post-blossom, fruitlet.	Lime-sulphur ¾-1%, derris 2 lb. per 100 gal.	Scab, red spider mite.
Post-blossom, small fruit.	Lead Arsenate 2 lb. per 100 gal.	Codling moth.

NOTE—Calendar times are approximate; spraying should be done at plant development stages. DNOC is a "one job" spray. If preferred, tar oil can be used during the dormant bud (Dec.-Jan.) period, followed by petroleum oil during the bud-breaking bud-burst period in March. DDT is sold normally as a 20% wettable powder; 5 lb. per 100 gal. is required to give a 0·1% spray concentration. Derris and lead arsenate are sold as wettable powders.

Warning—Some commercial varieties of apples will not tolerate lime-sulphur after blossoming. These should be given pre-blossom sprays only.

Pears

Prevalent pests and diseases—Aphids, caterpillars, codling moth, scab.

Time of spraying.	Materials.	Pests and diseases controlled.
Pre-blossom, dormant bud. Dec.–Mid.-Feb.	Tar oil 5%.	Aphids.
Pre-blossom, green cluster. Late March.	Lime-sulphur 2½% or Bordeaux 6-9-100, add DDT 0–1%.	Scab, caterpillars.
Pre-blossom, white bud. Mid-April.	Lime-sulphur 2% or Bordeaux 4-6-100.	Scab.
Pre-blossom, petal fall. Late April–early May.	Bordeaux 4-6-100, lead arsenate 2 lb. per 100 gal.	Scab, codling moth.
Post-blossom–fruitlet.	Bordeaux 4-6-100.	Scab.

NOTE—Calendar dates are approximate. Spray at development stages. The strengths of Bordeaux mixture are indicated by figures, thus 4-6-100 = 4 lb. copper sulphate, 6 lb. hydrated lime, 100 gal. water.

Warning—Some varieties of pears are damaged by post-blossom lime-sulphur sprayings—Bordeaux mixture is safer for pears after blossoming ***except Doyenne du Comice.***

Plums

Prevalent pests and diseases—Aphids, red spider mite, sawfly, caterpillars, bacteriosis, blossom wilt, silver leaf. The last named cannot be controlled by spraying—see Note below.

Time of spraying.	Materials.	Pests and diseases controlled.
Pre-blossom, dormant bud. February.	DNOC 5%.	Aphids, red spider mite, blossom wilt.
Pre-blossom, white bud. Early March.	DDT 0·1%.	Caterpillars.
Post-blossom, cot split. Early May.	Derris 2 lb. per 100 gal.	Sawfly.
Post-blossom, small fruit. Mid-May–Mid-June.	Bordeaux 4-6-100.	Bacterial Canker.
Post-blossom, fruitlet. Early June.	Lime-sulphur 1% or Derris 2 lb.–100 gal.	Red spider mite.

NOTE—Myrobalan plums should not be given the pre-blossom dormant bud spray. Where bacterial canker is prevalent a further spraying with colloidal copper should be given in latter half of June. Silver leaf is controlled by sanitation and preventive methods. All dead wood should be removed and destroyed by fire each year before Mid-June; any pruning of mature trees should be done in *early summer*.

Peach and Nectarine

Prevalent pests and diseases—Aphids, red spider mite, leaf-curl.

Time of spraying.	Materials.	Pests and diseases controlled.
Pre-blossom, dormant bud. December.	Tar oil 5%.	Aphids.
Pre-blossom, swelling bud. Late Feb.–Early March.	Lime-sulphur 3% or Bordeaux 4-6-100.	Leaf-curl, red spider mite.

Blackcurrants

Prevalent pests—Aphids, gall mite (big bud), midge, caterpillar, capsid.

Time of spraying.	Materials.	Pests and diseases controlled.
Pre-blossom, dormant bud. Dec.–Mid-Feb.	Tar oil 5%.	Aphids.
Pre-blossom, grape stage. Early April.	Lime-sulphur 2%.	Gall mite (big bud).
Blossom period. Late April.	DDT 0·1%.	Caterpillars, capsid, midge.
Post-blossom, fruitlet. Mid-May.	DDT 0·1%.	Midge.

NOTE—A few varieties of blackcurrants will not tolerate lime-sulphur at full strength. These should be sprayed with a weaker solution.

Raspberries

Prevalent pests and diseases—Aphids, beetle and cane spot.

Time of spraying.	Materials.	Pests and diseases controlled.
Pre-blossom, dormant bud. Dec.–Mid-Feb.	Tar oil 5%.	Aphids.
Pre-blossom, swelling bud. Mid-March.	Lime-sulphur 5% or Bordeaux 10-15-100.	Cane spot
Pre-blossom, bud breaking.	Bordeaux 4-6-100.	Cane spot
Post-blossom, fruitlet.	Derris 2 lb. 100 gal.	Beetle.

Blackberries

Prevalent pests—Aphids, capsids, beetle.

Time of spraying.	Materials.	Pests and diseases controlled.
re-blossom, dormant bud. Dec.–Mid-Feb.	Tar oil 5%.	Aphids.
re-blossom, flower bud. Early May.	DDT 0·1%.	Capsid.
lossom period. Late June.	Derris 2 lb.–100 gal.	Beetle.
ost-blossom, fruitlet.	Derris 2 lb.–100 gal.	Beetle.

Gooseberries

Prevalent pests and diseases—Aphids, red spider mite, caterillars, capsid, sawfly, mildew.

Time of spraying.	Materials.	Pests and diseases controlled.
re-blossom, dormant bud. Dec.–Jan.	Tar oil 5%.	Aphids.
re-blossom, buds opened. Early April.	Lime-sulphur 2½%.	Red spider mite, mildew.
ost-blossom, fruitlet. Late April.	Lime-sulphur ¾%, DDT 0·1%.	Mildew, caterpillar capsid, sawfly.

NOTE—Some varieties of gooseberry will not tolerate lime-sulphur raying. Dispersible and colloidal sulphur and proprietary sulphur eparations may be used in place of lime-sulphur. Follow makers' structions carefully.

Strawberries

Prevalent pests and diseases—Aphids, red spider mite, red core, ildew, blossom weevil.

Fruiting beds—Nicotine vapour applied by special machines, re-blossom (late April–Mid-May) and post picking (Mid-une–Aug.) to control aphids. HETP (8 oz.—100 gal. water *ith spreader)* as spray in spring and early summer to control phids and red spider. Flowers of sulphur (finely ground) or ecial sulphur dusts applied several times during spring and ummer to control mildew. DDT (wettable 20 per cent.) as 0·1 per cent. spray, mid to end of April (pre-blossom), to ontrol blossom weevil.

Runner beds—Nicotine vapour at end of June to control phids. HETP (8 oz.–100 gal. water) to control aphids in pring.

Runners—Dip (immerse) runners in nicotine solution (8 oz.-100 gal. water) before planting to destroy aphids ; add soft soap (one lb.) or wetter (as directed) to solution.

Approximate Quantity of Spray Solution required per Acre (Fully developed trees)

Cherries—600 gal. tar oil or DNOC ; 500 gal. other sprays. Apples—large standard, 600 gal. tar oil or DNOC ; 400 gal. lime-sulphur, lead arsenate or DDT. Medium trees—400 gal. tar oil or DNOC ; 300 gal. lime sulphur, lead arsenate or DDT. Small trees—200 gal. tar oil or DNOC ; 150 gal. lime sulphur. lead arsenate or DDT. Plums—400 gal. tar oil DNOC,, nicotine or derris. Pears—400 gal. tar oil or DNOC ; 300 gal. lime-sulphur. Currants—200 gal. tar oil ; 150–200 gal. lime-sulphur. Gooseberries—150 gal. tar oil ; 100 gal. lime-sulphur. Raspberries—100 gal. lime-sulphur, DDT and Bordeaux, 150 gal. derris or HETP. Strawberries—100 gal. DDT, 150 gal. HETP.

VEGETABLE GROWING

Planting and Sowing Tables

Number of plants required to plant a statute acre at various distances

Brassicas
(Brussels Sprouts, cauliflowers, cabbage)

Distance in inches	No. of plants
36×36	4,840
24×36	7,260
24×24	10,890
24×18	14,520
30×18	11,616
24×15	17,424
24×12	21,780
Celery	
54× 5	30,000
Onions and leeks	
12× 6	87,120
12× 7	69,696
12× 9	58,080
15× 6	69,696
18× 6	60,080
Asparagus	
48×18	7,260
60×18	5,804
36×18	9,680

Distance in inches	Lettuce	No. of plants
12×12		43,560
12× 9		58,080
15×12		34,848
15× 9		46,464
18×12		29,040
	Tomato	
36×18		9,680
36×24		7,260

Quantity of Seed required to sow a Statute Acre (approx.)

Beans, Broad, 1½ cwt. ; Dwarf or French, ¾ cwt. ; Runner (on flat), 1 cwt. Beet, 7 lb. Cabbage (drilled for greens), 5–6 lb. ; (for singling), 4 lb. Carrot (for bunching), 6 lb., (maincrop), 4 lb. Chicory, 8 lb. Cucumber, 2 lb. Lettuce, (drilled), 3 lb. Onion (drilled for bulbing), 6 lb. ; (drilled for bunching), 30 lb. Parsley, 4 lb. Parsnip, 6 lb. Peas, 1½ cwt. Radish, 56 lb. Spinach (round), 16 lb. ; (prickly), 20 lb. Swede, 3 lb. Sweet Corn 8 lb. Turnip, 2 lb. Vegetable Marrow (bush), 4 lb. ; (trailing), 2 lb.

NOTE—Under the Corn Sales Act (Jan. 1, 1923) seeds are bought and sold by weight and not by measure.

Quantity of Seed required per 50 ft. length of Drill—

Beet, 1 oz. ; carrot, radish, spinach, ½ oz. ; lettuce, onion, parsley, parsnip, turnip, swede, ¼ oz. ; beans, broad, 1 pint ; beans, French and Runner, ¾ pint ; peas (early), 1 pint ; peas (late), ¾ pint.

Quantity of Seed required for Broadcast Seed Beds

Brassica crops, 1 oz. to 6 sq. yards ; celery, 1 oz. to 9 sq. yards.

NOTE—One ounce of cauliflower, broccoli, cabbage or kale seed should produce not less than 3,000 plants, and one ounce of celery seed not less than 19,000 plants. One ounce of tomato seed should produce 3,000 plants.

Quantity of Seed required to provide Plants for Transplanting

For each acre to be planted—Asparagus, 2 lb. ; cabbage, 1 lb. ; cauliflower, ¾ lb. ; broccoli. ¾ lb. ; brussels sprouts, ¾ lb. ; celery, 2 oz. ; leek, 2 lb. ; lettuce, 2 lb. ; onion, 3 lb.; savoy, ¾ lb. ; tomato, ¼ lb.

SEED TESTING

Seeds Regulations made under the Seeds Act, 1920, apply to certain garden seeds. The Act requires that the garden seeds mentioned in the Regulations shall have been tested for purity and germination *before they are sold or exposed for sale* for seed purposes, and that particulars as to the percentage of purity, if below 97 per cent (carrot 90 per cent) and the percentage of germination (or if not less than the authorised minimum, a statement to the effect embodying the authorised minimum) shall be furnished to buyers of seed : Scheduled minimum germinations for vegetable seeds are as follows :—

	per cent		per cent
Garden peas	70	Brussels sprouts ...	70
Dwarf and broad beans	75	Broccoli	60
Runner beans ...	60	Cauliflower	60
Garden turnip and swede	75	Carrot	50
Cabbage	70	Parsnip	45
Kale	70	Beet (of clusters) ...	50
Köhl Rabi	70	Onion	60

Seed Germination

The longevity of seeds varies according to the kind and the method of storage. The table below gives the normal length of life for seeds when properly stored in a cool, dry, airy place :—

Asparagus	3 years	Parsley	3 years
Beans	3 years	Parsnip	1 year
Beet...	3 years	Peas	3 years
Cabbage	5 years	Radish	5 years
Carrot	3 years	Spinach	5 years
Cauliflower ...	5 years	Sweet Corn	1 year
Celery	6 years	Tomato	4 years
Cucumber	5 years	Turnip	5 years
Lettuce	5 years	Vegetable Marrow ...	5 years
Onion	1 year		

Seed Treatments to Control Diseases

Organo-Mercury—proprietary products (used as dusts): controls pre-emergency rotting, footrot, leaf and pod spot in peas.

Formaldehyde (Formalin) (used as weak water solution): controls leaf spot in celery.

Warm water immersion (122° F. for 15–20 min.): Controls canker in Brassicas.

Principal Containers used for Marketing Horticultural produce

RETURNABLES

Description.	Measurements in inches.	Produce for which used.
Bushel box (wood) ...	20 × 13½ × 10	Apples, pears, all vegetables.
Half-bushel box (wood)	16 × 11 × 7	Apples, pears, cherries, plums, gooseberries.
Quarter-bushel box (wood)	13 × 9¼ × 6 or 6¼	Cherries, currants, gooseberries, plums.
Broccoli crate (wood) ...	22½ × 14 × 14	Broccoli, Cauliflower, cabbage, carrots, leeks, turnips.
Lettuce crate (wood) ...	20 × 13 × 14	Lettuce, beans, spring onions, radishes.
Pot (wicker)	20 × 13 × 14	All vegetables.
Half-pot (wicker) ...	15 × 11¾ × 10	All vegetables.
Sieve (wicker)	Diameter 17, depth (side) 10½	Apples, pears, some vegetables.
Half-sieve (wicker) ...	Diameter 14½, depth (side) 9	Apples, pears, cherries, gooseberries, some vegetables.
Flat (wicker)	12 × 15 × 8	Asparagus, runner beans, cucumber.
Strike (wicker)	Diameter 11½, depth (side) 6¾	Currants, cherries, gooseberries, Tomatoes.
Cross-handle baskets ...	Various sizes	Tomatoes, grapes.
Bag	39 × 27	Roots, onions, cabbage, etc.
Half-bag	34 × 18	Roots, onions, cabbage, etc.

NON-RETURNABLES

Description.	Measurements in inches.	Produce for which used.
British Standard—		
Apple box ...	18 × 11½ × 10½	Apples and pears.
Half apple box ...	14½ × 9 × 9	Apples, pears, plums.
Quarter apple box	12½ × 7 × 7	Apples, pears, plums.
Tray (single layer) .	18 × 11½ × 3½	Apples, pears.
Tomato box	14 × 9 × 5½	Tomatoes (12 lb.).
Half-tomato box ...	11 × 7 × 4¾	Tomatoes (6 lb.).
Cucumber tray (single-layer)	22½ × 17 × 3	Cucumbers.
Lettuce crate (large) .	22½ × 16½ × 9	Lettuce, bunched carrots
Lettuce crate (small)	20 × 13 × 8	Spring onions, endive, etc.
Broccoli crate	22½ × 14 × 14	Broccoli, Cauliflower, cabbage.
Asparagus crate (12 bundles)	21 × 12 × 6	Asparagus.
Asparagus crate (6 bundles)	21 × 12 × 3½	Asparagus.
Chip basket	Several sizes to hold 2, 4, 6 and 12 lb.	Soft fruit, plums, cherries, tomatoes, mushrooms.
Punnets (square, round and rectangular)	Sizes to hold ¼, ½ and 1 lb.	Soft fruit, cherries, Mustard and cress.
Net bag (24 lb.)		Brussels sprouts.

THE SALE OF STRAWBERRY PLANTS AND BLACK-CURRANT BUSHES ORDER, 1946.

This Order requires that no person shall sell, offer or expose for sale or cause to be sold, offered or exposed for sale, or having sold, shall deliver or cause to be delivered any strawberry plants or blackcurrant bushes which are not the subject of a certificate issued by the Ministry of Agriculture for England and Wales or by the Board of Agriculture for the Isle of Man, or by the Department of Agriculture for Scotland or by the Ministry of Agriculture for Northern Ireland or by the Department of Agriculture for Eire.

Notwithstanding the above requirements—

(*a*) The sale of maiden bushes of blackcurrants which are grown from cuttings taken from blackcurrant bushes *which were the subject of a certificate issued in the preceding year* is allowed.

(*b*) Any strawberry plants or blackcurrant bushes which are the subject of a licence issued by the Minister, may be sold, offered or exposed for sale or planted.

Penalty for contravening the Order or for wilfully or negligently making any statement for the purpose of the Order—a sum not exceeding £10; for a second or subsequent offence—not exceeding £50.

THE SALE OF DISEASED PLANTS ORDERS, 1927, 1936-1941, 1943

(*The principal Order is that of* 1927)

Under these Orders it is an offence to sell, offer or expose for sale, or cause to be sold, offered or exposed for sale for planting, or having sold, to deliver or cause to be delivered for planting, any plant substantially affected by any insect or pest mentioned in the *First Schedule* or any plant which bears evidence of having been affected by any insect or pest mentioned in the *Second Schedule*.

First Schedule

(*a*) FRUIT AND OTHER TREE PESTS

Fruit Tree Cankers (caused by any parasitic fungi or bacteria).
American Gooseberry Mildew (*Sphaerotheca mors-uvae*).
Silver Leaf (*Stereum purpureum*).
Blackcurrant Mite (*Eriophyes ribis*).
Woolly Aphis (*Eriosoma lanigerum*).
All Scale Insects (*Coccidae*).
Brown Tail Moth (*Nygmia phoeorrhoea*).
Rhododendron Bug (*Leptobyrsa* (*Stephanitis*) *rhododendri*).

(*b*) VEGETABLE AND ROOT PEST

Powdery or Corky Scab of Potatoes (*Spongospora subterranea*).

Onion and Leek Smut (*Urocystis cepulae*).

Club Root or Finger and Toe Disease (*Plasmodiophora brassicae*).

Second Schedule

FRUIT TREE PEST

Apple Capsid (*Plesiocoris rugicollis*).

Additions to Schedules—The Order of 1936 extended the principal (1927) Order to include *inter alia* that the expression "any plant substantially attacked by any insect or pest mentioned in the First Schedule to this Order" in the principal Order shall be deemed for all the purposes of that Order to include any tomato or cucumber plant which is substantially affected by the insect or pest known as "Greenhouse White Fly" (*Trialeurodes vaporarium*), and any potatoes or Narcissus plants or bulbs which are visibly rendered unfit for planting by reason of their being or having been affected by any insect or pest.

Penalty for contravening the Order or failing to take such steps as are required under the Order or obstructing an Inspector—a sum not exceeding £10; for a second or subsequent offence—a sum not exceeding £50.

GLASSHOUSE CROPS

Standard Seed Raising and Potting Composts

JOHN INNES SEED COMPOST

Loam (steam sterilised and through ⅜-in. sieve), two parts (by bulk). Peat (up to ⅜-in.), one part (by bulk). Sand (coarse up o ⅛-in.).

Plus 2 lb. 18 per cent superphosphate and 1 lb. ground chalk or limestone per cubic yard, or 1½ oz. superphosphate and ¾-oz. ground chalk or limestone per bushel.

JOHN INNES POTTING COMPOST (Standard)

Loam (steam sterilised and through ⅜-in. sieve), seven parts by bulk). Peat (up to ⅜-in.), three parts (by bulk). Sand coarse up to ⅛-in.), two parts (by bulk).

Plus 5 lb. J.I. Base (see below), and 1 lb. ground limestone or chalk per cubic yard or 4 oz. J.I. Base and ¾-oz. limestone or halk per bushel.

JOHN INNES BASE

(Analysis (approx.) N5·1, P_2O_5 (soluble) 7·2, K_2O 9·7 per ent.) Hoof and horn, ⅛-in. grist (13 per cent N.), two parts by weight. Superphosphate (18 per cent. P_2O_5), two parts by weight. Sulphate of potash (48 per cent. K_2O), one part by weight.

NOTE—The J.I. Potting Composts are used with three concentrations of J.I. Base and chalk, viz., J.I.P.1, the standard potting compost, containing one dose of J.I. Base and chalk ; J.I.P.2, containing two doses of the standard amount of J.I. Base and chalk ; J.I.P.3, containing three doses of each. Growth in J.I.P.2 and J.I.P.3 is not necessarily improved or increased initially as compared with J.I.P.1, but the effect is prolonged. The made-up composts and the base are available through the horticultural trade channels.

Steam Sterilisation of Soil for Propagation

Pressure Steam (boiler pressure min. 40 lb. per sq. in.)—With suitable apparatus the soil is treated in bins, the soil depth not exceeding 12 in. *Steam* is kept on until all soil is at temperature of 212° F. (five to ten mins.). Steam is then turned off and the soil is left undisturbed for further 10 mins. before use.

CHEMICAL SOIL STERILISERS

Formaldehyde (40 per cent w/v. Formalin), (used as two pe cent water solution) : Glasshouse soils, controls soil-borne fungus diseases. Propagating soils—controls soil-borne fung Glasshouse and mushroom houses—general disinfectant.

Chloronitrobenzene, proprietary product (used as dusts control Botrytis and other soil-borne diseases.

Cresylic Acid (97–99 per cent purity) (used as dilute solution) : Glasshouse soils—controls root-knot eelworm, soi insect and animal pests.

MARKET GARDENING

A Calendar of Operations

NOTE—Planting and sowing times vary according to climatic conditions of the district.

JANUARY—*Open land*—Plough, lime and manure land cleared of crops. Cover rhubarb with long litter to advance growth. Lift rhubarb crowns as required for forcing. *Glass houses*—Sow tomato and cucumber for early main cropping Plant out lettuce. Sow radish, mustard and cress. Force mint Sow lettuce. *Frames*—Plant lettuce and sow radish in warm frames. Force asparagus on hot-beds. Give ventilation to plant frames on mild days. *Cloches*—Plant lettuce and sow carrot where soil is warmed. *Forcing Shed*—Force rhubarb chicory, seakale.

FEBRUARY—*Open land*—Finish ploughing, liming and manuring cleared land. Cultivate and prepare asparagus beds and ridges, apply fertiliser. Sow long-pod broad bean, first earl (round seeded) pea, radish (on early land), and parsnip fo opping. Plant shallots. Shake up litter over rhubarb to give ration. Plant early potatoes in warm areas. Cover seakale open land forcing. *Glasshouses*—Sow tomato and cucumber late main-cropping. Plant second crop lettuce. Force nt and salad chicory. Sow onion for plants. Plant cucumbers prepared borders. *Frames*—Sow early celery, lettuce, onion, uliflower, cabbage, early brussels sprout on warm-bed for ants. Sow turnip, carrot and radish in warm frames. Plant tuce in cold frames. Force asparagus on hot bed. Ventilate ant frames on mild days. *Cloches*—Plant lettuce, sow pea, rnip, carrot, radish in warm areas. Sow cauliflower for ants. *Forcing Shed*—Force rhubarb, chicory, seakale.

MARCH—*Open land*—Sow onion, early carrot, second-early a, long-pod and Windsor broad beans, parsnip and radish for opping. Sow leek, cabbage (summer), brussels sprout, uliflower for plants. Plant Jerusalem artichokes, early tatoes, asparagus, seakale, horse-radish, mint, rhubarb, tuce (from frames), onions (autumn sown) and garlic. ant cauliflowers from frames in warm areas. *Glasshouses*—ant tomatoes and cucumbers. Force mint, chicory. Sow an (for cropping under glass), tomato (for open land crop), elon (for crops under glass). *Frames*—Sow carrot and rnip in cold frames. Sow celery for plants. *Cloches*—Sow rnip, carrot, radish, globe beet, sweet corn. Plant lettuce and uliflowers. Cover strawberries. Sow lettuce for plants. *rcing Shed*—Continue forcing of chicory and seakale.

APRIL—*Open land*—Sow early beet, carrot, turnip, salsify, eet corn, radish, lettuce, spinach, parsley, maincrop pea and ench bean (in warm areas) for cropping. Sow cabbage, kale, occoli, savoys for plants. Plant onions (plants from glass uses and frames), cauliflowers (from frames), lettuce (from ames), second-early and maincrop potatoes, and mint. *Glass- uses*—Sow marrow and melon for plants. Transfer tomato ants to frames to harden for open land cropping. *Frames*—ant melon in warm frames. Harden tomato plants by venti- ing freely. *Cloches*—Plant tomatoes, sow French and runner ans, sweet corn, cucumber. De-cloche advanced crops as ather permits.

MAY—*Open land*—Sow carrot, turnip, runner bean, French an, endive, cos and cabbage lettuce, late beet, spinach, inach beet, ridge cucumber, gherkin, marrow, late pea, dish (on cool moist sites) for cropping. Plant cabbage ummer), brussels sprouts, cauliflowers, early broccoli, early ks, tomatoes, celery, New Zealand spinach. Sow broccoli, voy and cabbage for plants. Sow chicory for roots to force. *ames*—Plant melons and cucumbers on warm beds in cold

frames. *Cloches*—Plant melons end of month. Sow marro
Plant tomatoes.

JUNE—*Open land*—Finish cutting asparagus by middle
month. Finish pulling rhubarb and apply fertiliser to b
Sow carrot, turnip, endive, lettuce, late pea for cropp
Plant brussels sprouts, broccoli, winter cabbage, savoys, ce
and leeks. De-cloche ridge cucumbers and tomatoes. *Cloche*
Plant melons. De-cloche runner beans and sweet corn w
weather warm. *Glasshouses*—Second crop cucumber may
sown. Clean and re-soil houses before planting second crop

JULY—*Open land*—Sow French bean and carrot for
cropping. Harvest shallots. Sow spinach beet for croppi
Sow spring cabbage (late half of month) for plants. S
turnip for winter storage. Sow endive for autumn croppi
Cloches—De-cloche tomatoes and cucumbers.

AUGUST—*Open land*—Sow spring (salad) onion and wi
spinach for cropping. Sow onion, cabbage and lettuce (cos
cabbage) for autumn plants. Harvest autumn-sown onio
Plant strawberries. Mound up celery. Plant endive. *Glasshou*
—Plant tomatoes for late cropping. Sow French bean
ditto. *Cloches*—Sow French bean for late cropping.

SEPTEMBER—*Open land*—Harvest spring-sown onions. S
turnip for "turnip-tops." Plant spring-cabbage. Sow lett
(cabbage) for over-wintering crop. Mould celery. *Glasshou*
—clear tomato plants as crop finishes. Wash down and
infect houses. Arrange for soil steaming (if necessa
Frames—Prepare frame sites for sowing. Repair dama
lights. Sow cauliflower for plants. *Cloches*—Prepare clo
sites for cropping. Sow in open lettuce and cauliflower early
month for plants.

OCTOBER—*Open land*—Lift maincrop potatoes, carrots, b
turnips for storage. Lift chicory and seakale for forci
Clear asparagus beds and ridges of dead-growth and wee
re-soil and manure. Plant cos and cabbage lettuce for ov
wintering crops. Blanch endive. Mould celery. Trim, f
and manure rhubarb beds. *Glasshouses*—Steam soil of tom
houses ; trench and manure beds, apply basic fertiliser a
flood beds. Sow lettuce for plants. Lay in fuel stocks. *Fra*
—Sow cabbage lettuce. Sow further batch of cauliflow
Prick out plants of earlier sowing. Prepare sites and hot beds
warm frame cropping. Blanch endive in cold frames. *Cloche*
Cover lettuce and endive for autumn and early winter. S
lettuce and cauliflower Prick out cauliflowers and lettuce. *For*
Shed—Prepare for forcing season. Clean and disinfect shed a
beds. Prepare heating apparatus and lay in fuel stocks.

NOVEMBER—*Open land*—Plough and manure vacant land. Apply lime where necessary. Sow long-pod broad bean and round-seeded pea for early crops. Lift mint roots for forcing under glass. Lift rhubarb for forcing. Lay in stock of fertilisers. *Glasshouses*—Force mint. Plant lettuce for winter crops. Lay in fuel stocks. *Frames*—Prick out lettuce—Continue care of cold and warm frames. Blanch endive in cold frames. *Cloches*—Sow pea for early crop. *Forcing Shed*—Force rhubarb, seakale, chicory.

DECEMBER—*Open land*—Plough and manure vacant land. Apply lime where necessary. Tray seed potatoes for sprouting. Lift rhubarb and asparagus for forcing. *Glasshouses*—Prepare beds for, and sow mustard and cress. Force mint. Sow tomato and cucumber for early cropping. *Frames*—Give ventilation to plant frames on mild days. *Cloches*—Give ventilation on mild days. *Forcing Shed*—Force rhubarb, seakale, chicory.

DISEASES OF CROPS

CEREALS AND GRASSES

YELLOW RUST (*Puccinia glumarum*). The most damaging cereal rust in Britain. Affects wheat, barley and occasionally rye, but not oats. Also attacks certain grasses. Lemon-yellow pustules in parallel lines on leaves and stems. Scarce after very hard winters or unusually hot summers.

Control Measures :—Select resistant varieties.

BLACK RUST (*Puccinia graminis*). Occurs on wheat, oats, barley, rye and several grasses, but in Britain develops late and is rarely damaging. The fungus alternates between cereals and the common barberry (*Berberis vulgaris*). On cereals it forms reddish brown, later black, lines or spots on the leaf sheaths and stems : and on the barberry produces yellow or orange-coloured cluster cups.

Control Measures :—Where troublesome destroy barberry and choose the more resistant varieties.

BUNT OR STINKING SMUT (*Tilletia caries*). Common on wheat, rare on rye. Difficult to detect in growing crops. The grain of bunted ears becomes filled with a black mass of greasy spores that smell fishy. The bunted grains burst during threshing and the spores contaminate and discolour the healthy grain, spoiling it for milling and seed purposes.

Control Measures :—Disinfect the seed with an approved organo-mercury dust used at 2 oz. per bushel. Excess treated grain can be fed to poultry or pigs after washing it with water. If stored, must be kept dry and germination must be checked before sowing.

COVERED SMUT OF BARLEY (*Ustilago hordei*) and Oat Smuts (*U. kolleri* and *U. avenae*) are similar and can be prevented in the same manner.

LOOSE SMUT (*Ustilago tritici*). Affects only wheat, especially Vilmorin. The black smutty ears are conspicuous soon after emergence from the leaf sheaths.

Control Measures :—Use seed from clean crops only or apply hot water seed treatment, which is troublesome and tricky.

The Loose Smut of barley is a different fungus (*U. nuda*) but behaves similarly and can be overcome in the same way.

LEAF STRIPE (*Helminthosporium gramineum*) of barley and Leaf Spot (*H. avenae*) of oats occur mainly in the west and north. May kill young seedlings before emergence or produce brown stripes or spots on leaves and sheaths.

Control Measures :—Disinfect seed with organo-mercury dust.

TAKE-ALL (*Ophiobolus graminis*) affects wheat, barley and certain grasses (mainly couch, Yorkshire fog and bent) especially on light alkaline soils. Rye is resistant and oats almost immune to this fungus, but a special strain of it (var. *avenae*) occurs on oats, wheat and barley in Wales, north-west England and Scotland. Both fungi attack the roots leading to black discoloration at base of stem and empty bleached ears " Whiteheads ").

Control Measures :—Ensure a break from cereals every two or three years in the rotation. Keep down weeds. Apply phosphate to encourage root growth. Generously top dress with sulphate of ammonia not later than March.

EYESPOT (*Cercosporella herpotrichoides*). In spring causes oval, brown-bordered spots, shaped like an eye, near the base of the stems of wheat, barley and occasionally oats. Later. these weakened plants " lodge."

Control Measures :—Reduce frequency of wheat and barley in the rotation. Choose short strawed varieties and top dress generously with nitrogen.

MILDEW (*Erysiphe graminis*). On all cereals and most grasses When severe leads to badly filled ears and shrivelled grain Worst when mild winter followed by dry spring.

Control Measures :—Avoid too thick sowing and unbalance manuring. Sheep off in early spring when crop thick.

ERGOT (*Claviceps purpurea*) is commonest on rye and rye-grasses. Blackish " horns " up to ¾-in. long displace the young grains.

Control Measures :—Use clean seed, or seed freed from ergot by floating it in a saturated salt solution.

BLIND SEED DISEASE (*Phialea temulenta*) affects ryegrasses and occasional fescues. Can be recognised only in the seed Infected seeds are killed and seed samples containing them give low germination figures.

Control Measures :—Avoid infected seed stocks.

CHOKE (*Epichloe typhina*). White or yellow cylinders o fungus felt up to 2 in. long wrapping round leaves and stems o cocksfoot, timothy and other grasses. Infected plants neve recover. Interferes with seed production and possibly see transmitted.

Control Measures :—Further investigation necessary.

GREY LEAF (manganese deficiency) is most conspicuous in oats on alkaline soils. Grey or buff blotches and streaks on leaves, especially at margins.

Control Measures :—In spring apply 50 lb. per acre of manganese sulphate or, better still, spray with 1 per cent. solution of it.

POTATOES

BLIGHT (*Phytophthora infestans*). Produces dark blotches on leaves and in wet seasons may completely kill haulms. Also responsible for reddish-brown markings below skin of tubers, often leading to severe rotting in clamps. Likely to develop after periods when minimum temperatures not less than 50° F. and relative humidity above 75 per cent. for at least two days.

Control Measures :—Protect foliage by spraying maincrops twice, especially in coastal areas, with Bordeaux Mixture (10 lb. copper sulphate, 12½ lb. hydrated lime, 100 gal. water) or an approved copper product. In all districts protect tubers by cutting and removing haulm, or by killing it with sulphuric acid, sodium chlorate or tar acids a week or so before the crop is harvested. Some varieties are relatively resistant.

DRY ROT (*Fusarium caeruleum*) develops in stored tubers from December onwards, especially in early varieties. Large sunken, wrinkled areas, usually beset with white or pinkish spore pustules.

Control Measures :—Handle tubers carefully to avoid wounding. Dust with Fusarex at rate of 10 lb. dust per ton of tubers within 48 hours of lifting.

WART DISEASE (*Synchytrium endobioticum*) is scheduled as a notifiable disease. Produces greenish-yellow, warty, cauliflower-like growths on the tubers and on the stalks near soil level. Fungus remains alive in contaminated soil for many years.

Control Measures :—Grow immune varieties.

COMMON SCAB (*Actinomyces scabies*). Brown scurfy spots or patches on the tubers. Troublesome in sandy or gravelly, alkaline soils and on newly ploughed grassland.

Control Measures :—Plough in mustard, rye or vetches and apply acid-forming fertilisers. Some varieties are resistant.

POWDERY SCAB (*Spongospora subterranea*). Not always easy to distinguish from Common Scab. Rounded scabs on tubers or extensive cankered areas on second growth. Little damage except in wet districts and soils.

Control Measures :—Drain wet soils. Rotate crops.

BLACK LEG (*Bacterium phytophthorum*). From June onwards causes blackening of stem base, wilting of plants, and soft brown rot of tubers from heel end. Spread by use of diseased seed, and soil borne.

Control Measures :—Use sound seed.

Leaf Roll and Rugose Mosaic (viruses). Rolling of the lower or uppermost leaves, or dwarfed plants with yellow-green mosaic foliage. Tubers few and small, yields low.

Control Measures :—Always plant certified seed. Rogue out affected plants early.

ROOT CROPS

Club Root (*Plasmodiophora brassicae*). Also called Finger-and-Toe and Anbury. Causes swellings and contortions of roots of swede, turnip, rape, cabbage and other Brassica crops in acid soils.

Control Measures :—Incorporate freshly slaked burnt lime, hydrated lime or ground quick lime with the soil. This may take 18-24 months to work. Otherwise, long rotation (seven years or more) is necessary. Use resistant varieties of swedes and turnips. Raise plants in clean seed bed and where practicable dip cabbage seedlings, etc., in calomel paste (3 lb. calomel in 1 pint water per 300 plants) before transplanting.

Scab (*Actinomyces scabies*). Sometimes severe on turnip, sugar beet and mangold in alkaline soil.

Control Measures :—Checked by green manuring.

Black Leg (*Phoma betae* and *Pythium* spp.). Very young sugar beet and mangold seedlings become black and threadlike Seedlings wilt and die.

Control Measures :—The *Phoma* is seed borne and can b controlled by seed treatment with an organo-mercury dust.

Violet Root Rot (*Helicobasidium purpureum*). Attack many plants, including sugar beet, mangold, potato, carrot an clover. Affected parts become covered with purple felt o fungus mycelium.

Control Measures :—Careful rotation needed. Improv drainage.

Downy Mildew (*Peronospora schachtii*) of sugar beet an mangold causes heart leaves to become pale green, thickene and covered with lilac-grey downy fungus. Fungus spread from root to seed crops and vice-versa.

Control Measures :—Keep root and seed crops well separated

Yellow (virus) of sugar beet and mangolds. Outer an middle leaves become orange-yellow, thickened and brittle For every week a plant shows symptoms up to mid-Octobe it loses 5 per cent. of its potential yield of sugar.

Control Measures :—Keep root and seed crops separate Sow early. Clear mangold clamps by end of March.

Mosaic (virus) is also common but less damaging.

Heart Rot (*Boron deficiency*) of sugar beet and mangolds Usually in alkaline soils. Young leaves and growing point die

Brown decay round shoulder of tap root.

Control Meaures :—Apply 20 lb. borax per acre.

CARROT

Sclerotinia Disease (*Sclerotinia sclerotiorum*). Causes extensive rotting in storage, usually beginning at crown. Copious growth of white mycelium and black resting bodies.

Control Measures :—Destroy infected material. Ventilate store or clamp. Also attacks parsnip and beet.

PARSNIP

Canker (non-parasitic). Transverse cracking at crown of root, especially in broad shouldered sorts with stubby roots, often follows on certain weather conditions. Secondary organisms supervene. Apt to occur in lime-deficient soils and after unbalanced feeding with nitrogen. Often confused with injury due to carrot fly.

Control Measures :—Adequate fertilising is helpful.

FLAX AND LINSEED

Rust (*Melampsora lini*). Yellow or orange pustules on leaves, stems and flowers, followed later in year by black pustules.

Control Measures :—Grow resistant varieties. Avoid using seed from heavily rusted crops. Sow early.

Wilt (*Fusarium lini*). The main cause of flax " sickness." Plants wilt in patches. Fungus persists in soil for many years.

Control Measures :—Rotate crops or select resistant varieties.

Seedling Blight (*Colletotrichum linicola*), Stem-break and Browning (*Polyspora lini*) and certain other seed-borne diseases of flax and linseed can be prevented by routine seed treatment with tetra-methyl-thiuram-disulphide.

BEANS AND PEAS

Chocolate Spot (*Botrytis cinerea* and *B. fabae*). Sienna brown spots on leaves of field and broad beans. Becomes aggressive in warm wet weather after late spring frosts, and shoots then blackened and killed. Rarely bad on spring sown beans. Also occurs on vetches.

Control Measures :—Correct potash and phosphate deficiency.

Leap and Pod Spot (*Ascochyta* spp.) of peas. Brown or purple-brown spots on leaves, stems and pods. Seedlings often killed. Carried in seed.

Control Measures :—Sow only healthy seed. Follow sound rotation of crops.

Foot Rot (*Fusarium* spp.) of peas. Patches of plants die. Roots and stem bases brown or black and decayed. Often associated with eelworm on roots.

Control Measures :—Follow sound rotational cropping.

Pre-emergence Damping-off of peas. Seeds fail to germinate or seedlings rot before emergence. Occurs especially in early sowings if soil cold and wet.

Control Measures :—Overcome by seed treatment with organo-mercury dusts or with cuprous oxide.

Marsh Spot (manganese deficiency) of peas. Brown spot in centre of seed. Occurs mainly in marshy soils and wrinkled-seeded varieties.

Control Measures :—Spray with manganese sulphate at flowering time. Avoid overliming.

PASTURE AND FORAGE CROPS

Rot (*Sclerotinia trifoliorum*). One cause of clover "sickness." Especially on broad red clover. Frequent on trefoil, and on first-year sainfoin and lucerne. Plants rot off in irregular patches over field.

Control Measures :—Rotation of 8-12 years. Avoid sowing red clover among wheat after beans.

HOPS AND SOFT FRUIT

Downy Mildew (*Pseudoperonospora humuli*). Dwarf curled bines (basal spikes) in spring, followed later by similar lateral and terminal spikes. Fungus also causes angular leaf spotting and cone browning. The root stock when affected gradually rots. Affected parts become covered with dark grey, velvety, fungus growth.

Control Measures :—Remove and burn spikes. Spray four times with Bordeaux Mixture or approved proprietary, beginning when bine reaches top wire.

Wilt (*Verticillium albo-atrum* and *V. dahliae*). Occurs in two forms : a mild "fluctuating" form and a severe "progressive" wilt. Yellowing and browning of leaves followed by death of bine, which is usually thickened. "Progressive Wilt" is a notifiable disease.

Control Measures :—Destroy all wilting bines and grub badly affected hills. Plant sets from certified gardens using resistant varieties, e.g., Keyworth's Early or Keyworth's Mid-season.

Nettlehead (virus). Thin, weak and unfruitful bines which cannot climb properly.

Control Measures :—Grub affected plants. Mosaic (virus) plants with mottled foliage should also be rogued out. Plant sets from certified gardens. (See Hop varieties, page 117.)

Hop Mildew (*Sphaerotheca humuli*) forms white spots on leaves : attacks the "burr" (female flowers) preventing cone formation, and late attacks cause the cones to assume a foxy red colour—"Red Mould."

Control Measures :—Dusting with Flowers of Sulphur. Affected bines should be burned as soon as possible after picking the crop.

CANKER (*Fusarium sambucinum*) attacks the base of the bines causing them to become detached from the root-stock. Generally not a serious disease.

Control Measures :—Cut away dead portions of root-stock in spring.

AMERICAN GOOSEBERRY MILDEW (*Sphaerotheca mors-uvae*). Common on Gooseberry, occasional on currants. White or brown felt of fungus mycelium on leaves, young shoots and fruits.

Control Measures :—Spray with lime sulphur (1 in 100). With sulphur-shy varieties use washing soda-soap solution.

REVERSION (virus) of blackcurrant. Reverted leaves are longer and narrower than normal ones and have fewer and coarser marginal teeth. Affected bushes fail to crop.

Control Measures :—Plant only certified stock.

MOSAIC (virus) of raspberry. Vein yellowing, general chlorosis, or yellow spotting of leaves.

Control Measures :—Plant only certified stock.

YELLOW EDGE AND CRINKLE (viruses) of strawberry. Dwarfing of plants and yellowish margin to leaves in yellow edge (seen best in September) : small, light green or reddish spots on puckered leaves in crinkle (seen from June onwards).

Control Measures :—Plant certified runners only.

RED CORE (*Phytophthora fragariae*) of strawberry. Central cylinder of roots is red instead of white. Affected plants stunted and often collapse.

Control Measures :—Avoid contaminated soil. Plant clean runners. Use resistant varieties.

GARDEN PLANTS

(For diseases of potato, beet, pea, bean, carrot and parsnip see pages 197-199.)

CELERY—LEAF SPOT (*Septoria apii-graveolentis* and *S. apii*). Spotting and shrivelling of the leaves. Fungus carried on seed.

Control Measures :—Spray with Bordeaux Mixture or approved copper proprietary. Disinfect seed with formaldehyde.

LETTUCE—GREY MOULD (*Botrytis cinerea*). Decay of leaves and stems of young plants near soil level. A dusty grey mould develops on the affected parts. Winter lettuces suffer most.

Control Measures :—Select resistant varieties. Dust with penta-chloro-nitro-benzene. Good hygiene.

MOSAIC (virus). Affected plants dwarfed, with mottled and crinkled leaves. Transmitted with the seed.

Control Measures :—Control aphis. Use seed from healthy crops.

ONION AND SHALLOT—WHITE ROT (*Sclerotium cepivorum*). Plants wilt from June onwards. Roots killed and white fluffy fungus growth at base of bulbs.

Control Measures :—Ten years' rotation may be necessary. If onions grown in contaminated soil apply calomel treatment to seed (30 lb. calomel B.P. per bushel) or soil (1 lb. 4 per cent. calomel dust per 25 yards seed drill).

NECK ROT (*Botrytis allii*). Causes soft brown rot of stored bulbs. Rotted parts covered with grey felt.

Control Measures :—Dry bulbs well and store in cool place.

DOWNY MILDEW (*Peronospora destructor*). Yellowing, blotching and withering of leaves. Infected bulbs sprout prematurely.

Control Measures :—Separate spring and autumn sowings from one another and from seed crops.

TOMATO—LEAF MOULD (*Cladosporium fulvum*). Yellow patches on leaves with grey-brown velvety mould growth on underside. Mainly under glass.

Control Measures :—Ventilate well and keep temperature below 70° F. Spray with colloidal copper. Grow resistant varieties.

BLIGHT (*Phytophthora infestans*). On outdoor crops. Large dark spots on leaves, stems and fruits.

Control Measures :—Spray with half-strength Bordeaux Mixture or approved copper proprietary.

STEM ROT (*Didymella lycopersici*). Occurs in the open and under glass. Dark brown areas on stem at soil level or higher up. Also causes fruit rot.

Control Measures :—Good hygiene. Save seed only from healthy plants.

SPOTTED WILT (virus). Bronzing of younger foliage and stunting of plant. The virus is carried by Thrips and infects many ornamental plants.

Control Measures :—Do not grow tomatoes and ornamentals in same houses. Fumigate with nicotine.

BLOSSOM END ROT (non-parasitic). Dark green patch at blossom end of fruit. Caused by irregular watering.

TOP FRUIT

SCAB (*Venturia inaequalis* and *V. pirina*) of apple and pear. Olive-green patches on leaves and sooty scabs on fruit.

Control Measures :— Spray all but sensitive varieties with lime sulphur.

MILDEW (*Podosphaera leucotricha*) of apple. White mealy powder on young leaf trusses.

Control Measures :—Cut out infected shoots. Spray with lime sulphur.

Blossom Wilt (*Sclerotinia laxa*) of apple, pear, plum, cherry, peach and apricot. Wilting of flower trusses soon after blossoming, and cankering of spurs.

Control Measures :—Reduced by tar oil winter washing. Cut out infected spurs.

Brown Rot (*Sclerotinia fructigena*) of apple, pear and plum. Rapid brown rot of fruit beginning at wounds. Buff spore pustules on rotted parts. Fruits become mummified and hang on trees.

Control Measures :—Good orchard hygiene.

Silver Leaf (*Stereum purpureum*). Common on plum, cherry and peach, occasional on apple. Leaves show silvery or leaden sheen : branches die back and flattish purple fructifications develop on dead bark.

Control Measures :—Cut out all dead wood by 15th July. Cover fresh wounds with thick paint or grafting wax.

Bacterial Canker (*Pseudomonas mors-prunorum*) of plum and cherry. Shot-hole of leaves : sudden wilting and death of part or whole of tree in spring.

Control Measures :—Spray with Bordeaux Mixture in spring and autumn.

Leaf Curl (*Taphrina deformans*) of peach, nectarine and almond. Reddish, thickened, curled or distorted leaves.

Control Measures :—Spray just before buds swell with Bordeaux or Burgundy mixture.

Powdery Mildew (*Uncinula necator*) of vine. White mealy powder on leaves and young shoots.

Control Measures:—Dust with fine sulphur powder or use sulphur vaporiser.

INSECT PESTS OF CROPS

GENERAL FEEDERS

When grassland is ploughed up the following crops are able to be attacked by a number of insects or other pests. These include :—

WIREWORMS—the grubs of Click beetles (*Agriotes* spp.) which attack the roots of almost any crop and may bore into the above-ground parts of plants which are usually killed. Treatment consists of (*a*) summer fallowing ; (*b*) heavy rolling ; c) planting resistant crops such as peas or beans ; (*d*) treatment ith benzene hexachloride (BHC) insecticide, used broadcast, own with the seed or applied as a special seed treatment.

WHITE GRUBS—the larvae of the Cockchafer (*Melolontha ulgaris* L. and other species) are curved, thick white grubs and re root feeders. Treatment : (*a*) expose grubs by thorough ultivation ; (*b*) on a small scale treat soil or turf with BHC nsecticide.

CUTWORMS OR SURFACE CATERPILLARS—the grubs of Agrotid moths. These dark earth-coloured caterpillars attack chiefly oot crops. Plants are usually cut off about ground level. Treatment : (*a*) use Paris green and bran bait (see page 212) ; b) apply DDT insecticide dust.

LEATHERJACKETS—the legless grubs of Crane flies (*Tipula* spp.). ttacks occur only in the first year after ploughing up grassland nd are usually serious only under moist conditions. Treatment : (*a*) use Paris green and bran bait ; (*b*) on small scale pply BHC insecticide.

SLUGS—under moist conditions injurious to many crops, articularly on heavy land. Treatment : (*a*) use Paris green nd bran bait ; (*b*) use of metaldehyde bait.

EREALS

Wireworms, Leatherjackets and Slugs—see under GENERAL EEDERS.

GRAIN WEEVILS (*Calandra* spp.)—Attacks occur only in store. Treatment : Hygiene and, where possible, fumigation or treatment with DDT or BHC insecticides.

WHEAT BULB FLY (*Leptohylemyia coarctata* Fall.)—The mall white maggots of this fly attack seedling wheat if grown fter bare fallow or after patchy root crops. Where this pest prevalent, wheat after bare fallow should be avoided.

FRIT FLY (*Oscinella frit* L.)—The grubs or maggots of this fly are very small and attack seedling oats and oats in panicle. In the former case they occur low down in the central shoot; in the latter in the developing grain itself. Attacks may be avoided by early sowing.

GOUT FLY (*Chlorops pumilionis* Bjerk)—Developing ears of barley are "gouted" by the grubs; in the West country wheat is also attacked. Early sowing is very important in the case of barley. With wheat both very early and very late sowings should be avoided.

CEREAL ROOT EELWORM (*Heterodera major* (O. Schmidt))—This pest attacks the roots of oats and to a lesser extent other cereals. The enlarged females occur on the roots and drop off into the soil as cysts. Damage is avoided by sound rotational cropping.

STEM AND BULB EELWORM (*Ditylenchus dipsaci* (Kühn))—This eelworm attacks seedling oats. The pest is not visible to the naked eye. Affected plants are swollen and distorted. Avoid by adequate rotation and destruction of susceptible weeds.

POTATOES

Wireworms and Slugs—see under GENERAL FEEDERS

APHIDS (*Myzus persicae* Sulz., *Macrosiphum euphorbiae* Thomas, *Aulacorthum solani* Kalt, *Aphis rhamni* Fonsc.)—These are important pests of potatoes because they are vectors of virus diseases. They are not prevalent in the north and west where seed potatoes are grown. Direct injury by aphids is generally not severe and control measures doubtfully economic.

POTATO ROOT EELWORM (*Heterodera rostochiensis* Woll.)—A serious pest of potatoes causing "Potato Sickness." The roots are attacked and the "cysts" remain in the soil for long periods—serious damage may be avoided by sound rotational cropping. Tomatoes are also attacked.

POTATO TUBER EELWORM (*Ditylenchus destructor* Thorne)—The tubers are attacked and damage resembles "blight." Avoid planting infested tubers and eliminate the wild hosts, Horse Mint and Creeping Sowthistle.

TURNIPS, SWEDES AND OTHER BRASSICAE

Wireworms, Cutworms, Leatherjackets—see GENERAL FEEDERS.

TURNIP FLEA BEETLES (*Phyllotreta* spp.)—The adult beetles or "Fly" attack seedling plants immediately after they appear above ground, particularly in hot dry weather. Treatment: dust with DDT, BHC or Derris insecticide—two or three pplications may be necessary, the first as the plants are coming rough the ground.

CABBAGE BUTTERFLIES (*Pieris* spp.)—The caterpillars attack l kinds of Brassicae but particularly Brassicae in allotments nd gardens during the summer months. In severe attacks e leaves may be skeletonised. Treatment : use DDT nsecticide dust.

DIAMOND BACK MOTH (*Plutella maculipennis* L.)—Occasionlly the small caterpillars do extensive damage by feeding on e undersides of the leaves. Treatment : use DDT insecticide ust.

CABBAGE APHID (*Brevicoryne brassicae* L.)—This mealy phid occurs on all Brassicae but is chiefly a pest of Brassicae sed for human consumption. Treatment : use nicotine prays or dusts, or HETP spray 1 in 2,000.

CABBAGE ROOT EELWORM (*Heterodera cruciferae* Franklin)—his eelworm attacks the roots, the lemon-shaped cysts falling ff to remain in the soil. Attack may be avoided by sound otational cropping.

CABBAGE ROOT FLY (*Erioischia brassicae* Bché.)—One of the orst pests of Brassicae grown for human consumption, and ometimes particularly severe on cauliflowers. The maggot-ke grubs feed on the roots which may be completely destroyed. ometimes found boring into the necks of turnips and swedes. reatment : apply calomel dust (4 per cent.) or BHC insecticide ose around the base of the stem of plants shortly after planting ut. Under poor growing conditions a second application ay be necessary.

On Brassica Seed Crops the most serious pests are BLOSSOM EETLE (*Meligethes* spp.), CABBAGE SEED POD WEEVIL (*Ceuthoynchus assimilis* Payk.), BRASSICA POD MIDGE (*Dasyneura rassicae* Winn). Treatment : Use BHC, DDT or pyrethrum nsecticide dusts.

ULSE

Wireworms, Cutworms and Leatherjackets—see under ENERAL FEEDERS.

PEA AND BEAN WEEVILS (*Sitona* spp.)—The adult weevils bite emispherical notches out of the leaves. Damage is most evere under hot dry conditions when plants make little growth. reatment : Use a DDT or BHC insecticidal dust.

PEA MOTH (*Cydia nigricana* Steph.) The small caterpillars ore into the pods and devour the peas. Treatment : Spray ith DDT emulsion (¼-per cent.) ten days after the beginning f flowering.

PEA EELWORM (*Heterodera göttinginana* Liebs.)—The roots f peas are attacked and the swollen female " cysts " drop off into the soil causing the condition known as Pea Sickness May be avoided by sound rotational cropping.

SUGAR BEET AND MANGOLDS

Mangold Flea Beetle (*Chaetocnema concinna* Marsh).–Adults attack the seedling plants as with Turnip Flea Beetles Treatment : Use DDT or BHC insecticidal dusts in the ver early stages of growth.

Pygmy Mangold Beetle (*Atomaria linearis* Steph.)—Th minute adult beetles attack the roots of seedlings below ground Avoided by sound rotational cropping.

Mangold Fly (*Pegomyia betae* Curt.)—The white maggot like grubs mine in the leaves. Severe only in some years Treatment : Use a sodium fluoride and molasses bait spra or BHC insecticidal dust should be tried.

Black Bean Aphid (*Aphis fabae* Scop.)—The centre leave are first attacked by this Black-fly. Treatment : The primar infestations in beet or mangold crops should be destroye For later attacks use nicotine or HETP insecticide.

Beet Eelworm (*Heterodera schachtii* Schmidt.)—" Bee Sickness." The eelworms attack the roots of beet and mar golds and lemon-shaped cysts fall off and are left in the soi The eelworm also lives in the roots of certain brassicae and o a few weeds. In affected areas rotation of the beet crop an restrictions on planting are imposed under the Sugar Bee Eelworm Orders of 1943 and 1950.

PASTURE AND FORAGE CROPS

Garden Chafer (*Phyllopertha horticola* L.)—see unde General Feeders. This pest may swarm in large numbe in June, the grubs feeding on the roots of grasses just belo ground level so that the turf may be rolled up like a mat. Th use of insecticides is uneconomic on a field scale. Harrowin and re-sowing is recommended.

Antler Moth (*Cerapteryx graminis* L.)—A pest of uplan and mountainside grazings. The caterpillars sometimes occu in enormous numbers and leave the ground almost bare. Th use of BHC insecticidal dust should be tried in the early stag of an attack.

Aphids—Grass aphids are only very occasionally seriou pests. The species mainly concerned are *Metopolophiu festucae* Theob. and *Rhopalosiphum padi* L. Attacks occu under hot dry conditions ; valuable crops may be treate with HETP insecticides but treatment may not be economic o ordinary grassland.

Clover Weevils (*Apion* spp.)—The grubs of these ver minute weevils feed in the clover heads and devour th developing seeds thus the yield of seed crops may be serious duced. Serious damage may be avoided by growing crops ay from old clover stocks and by reducing shelter for the dults. Considerable success has followed the use of DDT d BHC dusts.

STEM AND BULB EELWORM (*Ditylenchus dipsaci* Kühn)—his pest causes "Clover Sickness." Plants are stunted and ternodes much reduced and thickened. In severe cases the op may die out. Avoid by sound rotational cropping.

ARROTS, PARSNIPS AND ONIONS

Wireworms and Cutworms—see under GENERAL FEEDERS.

CARROT FLY (*Psila rosae* L.)—A widespread and severe pest carrots in both field and garden. The grubs bore into the ots, causing them to become "rusty." Seedling carrots may killed. Treatment: Spray around hedges and ditches ith a sodium fluoride bait or with DDT emulsion. In gardens ray the whole crop. This pest is only occasionally severe parsnips.

APHIDS—The most common species is the Carrot Aphid *avariella aegopodii* Scop. Occasionally a severe pest of carrots uring periods of hot dry weather. May be controlled with cotine or HETP spray.

ONION FLY (*Delia antiqua* Meig.)—The white grubs bore into e developing bulbs of seedling plants in the spring and early mmer. Treatment: Seed may be treated with a calomel-flour ste, or 4 per cent. calomel dust should be dusted along the ws of seedlings soon after the plants show above ground: o treatments may be necessary.

STEM AND BULB EELWORM (*Ditylenchus dipsaci* Kühn)—is pest causes a condition known as "bloat"; bulbs become ft and useless. Avoid by sound rotational cropping and mplete destruction of all affected material.

AX AND LINSEED

Wireworms and Leatherjackets—see under GENERAL FEEDERS. Flax is one of the crops most resistant to wireworms but therjackets can be very destructive.

FLAX FLEA BEETLES (*Longitarsus parvulus* Payk. and *Aphthona horbiae* Schr.). These may become serious pests if flax is own intensively. DDT or BHC insecticides should be tried en infestations become severe.

(For insects injurious to garden vegetables see pages 206-209.)

UIT TREES

APPLE BLOSSOM WEEVIL (*Anthonomus pomorum* L.)—A pest apple only, the grubs feed in the unopened flowers causing apped" blossoms. Treatment: Use DDT dust, 5 per cent., spray with 0.05 per cent. DDT, during the week preceding bud burst. In gardens adult weevils may be trapped in sacking bands placed around the tree trunks.

Winter Moths (*Operophtera brumata* L., *Hybernia defoliaria* Cl., *Erranis aescularia* Schiff.)—The caterpillars of these moths feed on the foliage of all top fruit—if unchecked they may cause almost complete defoliation. Treatment : Grease band tree trunks in autumn—use combined emulsion of DNC—petroleum oil wash in winter to kill the eggs or spray in spring with lead arsenate using 2 lb. powder or 4 lb. paste to 100 gal. water or add the arsenate to a fungicide spray.

Codling Moth (*Cydia pomonella* L.)—The caterpillar bores into apples and feeds on the pips. Treatment : Spray with lead arsenate in June about a fortnight after blossoming to kill the young caterpillars before they bore into the apples. Use sack or corrugated paper bands around trunks to catch the caterpillars.

Aphids—On Apple (*Aphis pomi* De Geer, *Sappaphis plantaginea* Pass. and *Rhopalosiphum insertum* Wlk.).

On Plum (*Brachycaudus helichrysi* Kalt. and *Hyalopterus arundinis* Fab.).

On Cherry (*Myzus cerasi* Fab.)—Unless adequately controlled damage by aphids due to leaf curling and the deposition of " honey dew " makes commercial fruit growing uneconomic. All are readily controlled by winter spraying with tar oil or petroleum-DNC washes to kill the eggs which are laid on the twigs and branches. In summer a nicotine wash may be used, but when the leaves are badly curled control is difficult and uneconomic.

The Woolly Aphid (*Eriosoma lanigerum* Haus.) is no readily controlled by winter washing. A nicotine spray may be necessary, or the parasite — *Aphelinus mali* — may be introduced.

Apple Sawfly (*Hoplocampa testudinea* Klug.)—The grub bore holes in and live inside developing apples—the damage i like that caused by Codling Moth but occurs earlier and i severe when apples are about the size of marbles. Treatment Spray at petal fall with a nicotine or BHC insecticide.

Plum Sawfly (*Hoplocampa flava* L.)—A severe pest of plum and damsons in some districts. Damage similar to appl sawfly. Treatment : Spray with a Derris wash when th " cots " are beginning to split.

Apple Capsid (*Plesiocoris rugicollis* Fall.)—Causes sever scarring of apple fruit in spring and early summer. Treatment Spray with petroleum wash or DNC-petroleum oil wash i late winter or early spring to kill the eggs. May also be con trolled in spring by spraying with DDT wash, 0.1 per cent

Fruit Tree Red Spider Mite (*Metatetranychus ulmi* Koch

—These small mites feed on the backs of the leaves of a number of trees and can cause severe damage to apple and plum trees late in the season. Leaves become prematurely russeted and the crop is reduced. Treatment : Spray with petroleum oil wash or DNC-petroleum oil wash in winter to kill the eggs. In early June spray with a Derris wash using 2-2½ lb. of powder (2 per cent. rotenone) to 100 gal. water.

SOFT FRUIT

Raspberry Beetle (*Byturus tomentosus* Fab.)—The adults feed on the flowers and the grubs feed on and in raspberries, loganberries and blackberries. Treatment : Use Derris dust to kill adults before the flowers open or spray with Derris, 2-2½ lb. to 100 gals. of water, at the end of the blossoming period—late June for raspberries and a fortnight or three weeks later for loganberries and blackberries.

Aphids on Gooseberries and Blackcurrants. Cause severe leaf curl and leaf blistering. Treatment : Use tar oil winter washes as for Top Fruit.

Aphids on Strawberries—The important species is the Strawberry Aphid (*Pentatrichopus fragaefolii* Ckll.). It is a vector of virus diseases. Treatment : Use nicotine or HETP spray.

Gooseberry Sawfly (*Pteronidea ribesii* Scop.)—The grubs defoliate bushes in the summer. Generally a serious pest only in gardens or small orchards. Treatment : Spray with Derris wash—3-4 oz. powder, ½-lb. soft soap, 10 gal. water—or DDT wash, 4 oz. powder, ½-lb. soft soap, 10 gal. water—or DDT wash—4 oz. of 20 per cent. wettable powder to 10 gal. water—at end of April after the blossoming period.

Blackcurrant Gall Mite (*Phytoptus ribis* Westw.)—Causes "Big Bud" of blackcurrants. Infested buds are globular and about twice normal size. Treatment : Spray with lime sulphur wash (2 per cent.) in early spring at the "grape" stage. In the west and south-west use only 1 per cent. solution on "sulphur-shy" varieties.

COMMON INSECTICIDES

The more general formulae used are given—but different strengths are used for some pests.

Derris—The ground root of a Malayan plant. Poisonous to fish—non-poisonous to warm blooded animals. Used as eady-made dust or for dilution with water use 2-2½ lb. wettable powder to 100 gal. water with a spreader.

Nicotine—A contact poison for use against sucking insects. The concentrate—95-98 per cent. nicotine—is very poisonous. Used as 3 per cent. dust or as dilute spray—nicotine 8 oz. to 100 gal. water with a spreader.

Paris Green—A poisonous arsenical generally mixed with bran to form a poison bait. Use 1 lb. Paris Green to 25 lb. bran—this quantity being sufficient to broadcast over one acre.

Lead Arsenate—Very poisonous. Used against biting insects in spray form. Use 2 lb. powder or 4 lb. paste to 100 gal. water.

DDT (dichloro-diphenyl-trichloroethane)—Should be kept away from foodstuffs and handled with care. Used as 5 per cent. dust or as wettable spray or emulsion at strengths varying from 0.025 to 0.1 per cent. DDT. 0.05 per cent. DDT = ½-lb. DDT per 100 gal. water or 4 lb. of 25 per cent. wettable DDT powder/100 gal. water.

BHC (benzene hexachloride)—Should be kept away from foodstuffs and handled with care. Generally used as 2-3½ per cent. dust or as seed dressing. The dusts should not be used on soils which are to grow potatoes or root vegetables because of risk of taint. There is no risk of taint following the use of the seed dressing.

HETP (hexaethyl tetra phosphate)—Very poisonous in concentrated form. Used as spray at a dilution of 1 to 2,000.

Winter Washes for Fruit Trees—These are generally in the form of miscible oils ready for dilution with water. The following may be used.

(i) Tar oil wash at 5-10 per cent. dilution.
(ii) Tar oil—mineral oil wash at 10 per cent. dilution.
(iii) Mineral oil wash at 6-7½ per cent. dilution (also used as refined summer oil at 1 per cent. dilution).
(iv) DNC (dinitro-ortho-cresol) washes—more poisonous than tar oils and stain the skin yellow. Protective clothing should be used for spraying. Generally diluted to 7½ per cent. to give 0.1 per cent. DNC and 5 per cent. mineral oil.

Lime Sulphur—A valuable product for the control of mites. Used at dilutions varying from 1-3 per cent. N.B.—Some varieties of fruit trees will stand more concentrated lime sulphur wash than others and some should not be sprayed at all with lime sulphur.

Metaldehyde—A solid fuel used for mixing with bran to form a bait for slugs and snails. Use ½-lb. to 28 lb. bran and moisten. This quantity is sufficient for an acre. For gardens 1 oz. metaldehyde to 3 lb. bran.

THE DESTRUCTIVE INSECTS AND PESTS ACTS, 1877 to 1927

These Acts enable action to be taken in England and Wales against any insect, fungus, bacterium or virus destructive to agricultural or horticultural crops, including trees and bushes.

Action is taken through the issue of special Orders made under the Acts.

The Importation of Plants Orders of 1947-1949 are designed to prevent the introduction of pests and diseases on plants imported from overseas. They apply to all living plants and parts of plants (except seeds) intended for planting, as well as to all potatoes, raw vegetables and certain raw apples. Special Orders deal with the Importation of Raw Cherries and with the Importation of Forest Trees.

The Destructive Insects and Pests Order of 1933 enables steps to be taken to prevent the spread of any insect, fungus, etc., which is destructive to horticultural or agricultural plants and which is not established in Great Britain. Special measures against Colorado beetle are taken under the Colorado Beetle Order of 1933.

The Silver Leaf Order of 1923 requires the occupier of land where apple and plum trees are growing to destroy by fire on the premises all dead wood of these trees before 15th July in each year.

The Wart diseases of Potatoes Order of 1941 makes wart disease a notifiable one and prohibits the planting of any but approved immune varieties on land where wart has occurred.

The Progressive Verticillium Wilt of Hops Order of 1947 makes this disease a notifiable one, requires dead and dying bines and leaves of affected hops to be burnt, and prohibits the sale, except under licence, of hop plants and parts grown on land where the disease has occurred.

The Sugar-Beet Eelworm Order of 1943 is designed to control and to prevent the further spread of sugar beet eelworm.

Insecticides and Fungicides—At one time insecticides and fungicides were few in number, simple in character, and usually easy to make up on the farm or in the orchard. A few, like Bordeaux and Burgundy mixtures, still survive and the formulae for preparing them are given on page 214. The others have now been displaced by ready-made proprietary products old under brand names. These newer insecticides and fungicides contain chemicals of a complex nature : most of them cannot be prepared at home and must be purchased in products suitably compounded by a chemical manufacturer. In order to help he grower to choose the one he wants from the many proprietaries now available, the Ministry of Agriculture and Fisheries in 1943 began what is now called the Crop Protection Products Approval Scheme. This scheme enables the manufacturer to seek approval, under certain specified conditions, for those of his products which are marketed in Great Britain for the purpose of crop protection. Products that are approved carry a special diamond-shaped mark on the container, so that the consumer can see at a glance that what he is buying is satisfactory for his purpose. When buying proprietary insecticides and fungicides always buy an officially approved product.

Bordeaux Mixture :

Copper sulphate (powdered or granular)	10 lb.
Lime (best hydrated)	12½ lb.
Water	100 gals.

Burgundy mixture contains 12½ lbs. of washing soda instead of hydrated lime. The copper sulphate should be at least 98 per cent. pure and the hydrated lime purchased fresh.

In preparing the mixture the copper sulphate should be dissolved in 5 gallons of water and the lime or washing soda in 95 gallons. The two solutions should then be mixed.

WEEDS AND WEED CONTROL

Harm Done by Weeds—Weeds compete with the crop for light, plant foods and water. Of these water is most affected by weeds and reduction in yield of crop results. Plant foods are not lost to the soil if the weeds are not removed from the land and they can in any case be replaced in the form of fertilisers. Young crops in the process of establishment suffer from competition for light and vigorous seedling weeds may choke the less vigorous crop plants.

Weeds also act as hosts for insect pests and fungus diseases. Thus Mangel Fly (*Pegomyia hyoscyami v betae curtis*) is common o Goosefoot as well as to sugar beet and mangels ; Club-root (*Plasmodiophora brassicae*) attacks Charlock as well as swedes and turnips ; wayside umbelliferous weeds are hosts for Celery Rust (*Septoria apii*).

Weeds, such as Wild Onion, may impart a bad taste and smell to wheat flour ; Ramsons may give milk an onion flavour; the seeds of Corn Cockle may be poisonous if ground with grain.

Weeds in pastures and leys reduce the grazing area, either by occupying ground in place of good grasses or by acting as barriers to stock. Sheep and cattle will not graze amongst colonies of Creeping Thistle and sheep will avoid ground where even the stumps of cut thistles are present.

A small number of weeds may be classed as poisonous to ivestock, but there is a vast number alleged to be poisonous though conclusive proof is lacking. So many factors are involved such as the health, age and size of the animal, the amount of food in the stomach, the stage of growth of the weed, to mention a few, that the whole problem is very involved.

Lastly, weeds always convey the impression of neglect.

METHODS OF WEED CONTROL

Control at the Source—Seed Catchers : There no practicable methods for destroying weed seeds on the ground after hey have been shed. During the cutting of cereal crops by the elf-binder large quantities of weed seeds can be prevented from alling to the ground by using a seed-catching device. This consists of a bag held open by a metal frame and fastened to the edge of the binder deck. The open bottom is looped up o the edge of the deck and may be opened easily to empty the bag.

Threshing : Many weed seeds are removed from cereal and pulse crops during threshing and are delivered by a chute to a place under the machine. They should be collected and burnt or sold as bird seed.

Stubble Cleaning : By producing a shallow seed bed on the stubble after harvest the immediate germination of weed seeds is encouraged. A subsequent stirring of the soil destroys the seedlings and brings fresh seed to the surface to germinate in its turn. Twitch may be dragged out at the same time as these operations are effected.

The shallow seed bed is best produced by fitting broadshares on to a rigid tined cultivator. The shares should overlap to cover all the ground and they should work to a depth of about 2 in.

If stubbles are hard and a broadshare will not face them, heavy disc-harrows may be used.

Operations should commence between the stooks, immediately after cutting and setting up. This gives the maximum of time before winter sets in. The work should be carried out about once a fortnight for as long as weather permits.

Stubble cleaning is not completely effective in germinating all weed seeds brought to the surface, for the seeds of many species have a dormant period which may last a year or more and may be due to a thick hard seed coat or to an immature condition of the seed at shedding.

Where dormancy is enforced, through deep burying or through storing the seed under dry conditions, the seed may remain viable for long periods ; some seeds retain their germinating powers for over 80 years.

Control by Cultivation—Ploughing : Runner bearing grasses known collectively as "twitch" may be destroyed effectively by ploughing them under and leaving them undisturbed for a year or two. A depth of soil of not less than 10 inches is necessary to ensure proper burying so that subsequent cultivations will not disturb them.

A digger plough is best and should be adjusted to turn the furrows over completely and leave no seams between the furrow slices. A skim coulter helps to invert the furrow slice properly.

Hand Hoeing : Despite progress in mechanisation a great deal of weeding must still be done by hand.

There is a vast number of hoe types on the market. The blades should be sharpened easily or be interchangeable and set at the proper pitch.

Flexible Harrows : A comparatively new method of cleaning land in the early stages of crop growth has originated from Central Europe. This consists of using light flexible harrows with short teeth. When used in root crops, it is essential that they should be grown on the flat. Work commences before the crop emerges and continues at intervals, usually of seven to ten days, until it is too advanced in growth to resist damage.

The method can only be applied safely to mangels and sugar beet where the seed and seedlings are not easily disturbed. Seedling weeds are destroyed because the seed germinates near the surface.

Harrowing : The true harrow is a scarifier and according to the shape of the tines, may be used for knocking out seedling weeds or pulverising small clods. Curved tines are employed to scoop weeds to the surface. The chief advantages of the spring tined harrow are that the depth of the tines is adjustable and being springy, there is not such a dead pull as with ordinary harrows.

Chain harrows are composed of chain links, sometimes fitted with tines. Their chief use is for spreading dung on grassland, but they may be used for dislodging weed seedlings in young corn or for rolling up twitch. They are used sometimes for destroying seedling weeds on potato ridges.

Horse Hoeing : This term covers row crop cleaning implements drawn by tractors as well as horse-drawn implements that are similar in principle.

In cleaning row crops either by horse or tractor, the implement follows in the same rows as those in which the drill worked. The horse-drawn implement requires steerage but the tractor drawn one may be fixed rigidly to the tractor or may be hitched to work independently. In the former case it is the tractor that is steered, in the latter the implement has a separate steerage arrangement.

Generally, L blades only are used on these row crop implements. They are staggered to avoid choking. The vertical part of the L blade adjoins the row of plants and in the angle of the L there is usually a lip projecting inwards and backwards to clear soil and weeds from the plants. On some models, discs and A blades may be used.

Frequent cleaning in this manner, using a tractor, tends to pack the land and many experienced root growers are returning to the horse.

In cleaning crops grown on ridges, it is not possible to work so deeply on the sides of the ridges, especially in potato crops. The implements consist, in principle, of tines for working the bottoms between the ridges and what are known as side hoes are fitted to work the sides of the ridges, if these are high. Expanding horse-hoes for different widths of ridge are available.

For working tips and sides of ridges only, saddle or bow harrows can be used, but this work merely knocks out annual weed seedlings.

Summer or Bare Fallowing : Summer fallowing implies that the land is cultivated for a whole summer without a crop for the sole purpose of destroying obstinate species of weeds, such as twitch.

In summer fallowing the furrow slice should be kept intact, the object being to bake the soil and destroy the twitch by shrivelling. If the soil is broken down, as with cultivators, it becomes moist and the twitch runners are propagated. The best method is to plough as often as possible. Simply turning the furrow slices or the clods over to be baked on the opposite face. Summer fallowing does not succeed on sandy soils or in wet districts.

A modified system is that of " pin " or " bastard " fallowing, whereby a crop is grown that can be harvested in summer. Early potatoes or silage may be taken as examples. After harvesting the crop, the rest of the summer is devoted to cleaning the land.

Smother Crops : The practice of destroying or suppressing weeds by growing a smother crop is one that requires caution. Unless the smother crop has a flying start, the weeds may gain the lead and so smother the crop. Heavy crops of leafy oats or silage mixtures are sometimes employed for this purpose, but the most effective crop is marrow-stem kale. In the latter case it is not the canopy of kale leaves that suppresses the weed, but the intense root competition.

Rotation of Crops : If the principle of rotations is neglected and one crop is grown several years in succession, or at too frequent intervals, then the system of cultivation for that crop or its habits of growth may favour a certain group of weeds. These weeds may thus gain the ascendency. A common example is the increase in the amount of charlock or of twitch, when cereals are grown too often.

On the other hand a rotation may be modified to combat a certain weed. Two potato crops in succession, if they are properly worked, will rid land of twitch. It is claimed that two root crops in succession will reduce a charlock infestation to negligible proportions.

Systems of livestock husbandry may develop their characteristic weeds. Pigs produce a definite association of about four weeds ; sheep often control ragwort and destroy sheep's parsley completely ; heavy grazing kills couch and creeping bent.

Draining : Some weeds are native to damp places and drainage is the obvious remedy, though it may not always be possible. Rushes, marsh thistle, marsh horsetail and Yorkshire-fog are common in wet pastures. Redshank is a weed of wet arable land and is a most reliable indicator of water impedance or a high water table, though the soil may be dry on the surface.

Chemical Control—Weed killers may be divided into two main groups, soil sterilants that kill all plant life and selective weed killers that destroy certain weeds but not the crop plants.

The principle of selective destruction is not completely understood but it depends fundamentally upon some anatomical or physiological difference between weeds and the crop. It is probably due to the fact that the weeds are dicotyledons and the crops are monocotyledons.

Soil Sterilants : The chemicals used most frequently for this purpose are sodium chlorate and arsenic. The latter is extremely dangerous and its use should be avoided in a densely populated country like Great Britain.

The term " soil sterilant " is somewhat misleading and some people prefer the term " non-selective weed killer." Almost any chemical will destroy plant life if used in sufficient quantities.

Sodium chlorate is extremely toxic to plant life, but is harmless to animals and man. It is, however, explosive and inflammable. To overcome the latter objection, a proprietary preparation combines sodium chlorate and calcium chloride. This ensures that the mixture becomes wet on exposure.

The use of sodium chlorate in agriculture is limited, as it is only of value for weed destruction on roadways, in yards and on land that will not be cultivated. To such places it may be applied at the rate of 25 to 50 lb. per acre of the chemical. This is usually diluted in 50 to 100 gallons of water and applied as a spray.

The practice of destroying twitch by dressing the land with 2 cwt. of sodium chlorate per acre, and then leaving fallow for 6 months, has certain dangers. In any case the cost is usually prohibitive.

Selective Sprays : The chemicals used most frequently as selective sprays are sulphuric acid, copper sulphate, copper chloride, D.N.O.C. (di-nitro-ortho-cresylate) and the new " hormone " weed killers. The latter are known as M.C.P.A. (4-chloro-2-methyl-phenoxyacetic acid) and D.C.P.A. (2 : 4-dichlorophenoxyacetic acid). They are sold under a variety of proprietary names.

One of the dangers involved in selective killing, is that the destruction of the dominant weed may leave a free field for a weed that is resistant to the chemical that is used. There is some evidence that the use of sulphuric acid for the destruction of charlock and wild radish has led to an increase in smooth leaved charlock or wild rape as this weed has a waxy cuticle and is resistant to acid.

Methods of Application—Weed killers may be applied as sprays in solution, as dusts applied by a dusting device or may be incorporated with an inert powder and sown through a fertiliser distributor. This latter development in the application of the "hormone" weed killers has been a great boon obviating the use of a sprayer and the provision of large quantities of clean water.

Sprayers are usually lead lined to take acid or other corrosive material and the common rate of application is 100 gallons per acre. New types of "low volume" sprayers have been developed in an attempt to solve the water problem and the application of as little as 5 gallons per acre of solution is possible.

Spraying should generally be undertaken by experienced contractors.

The successful dusting of weeds in growing crops with a selective weed killer is dependent on favourable weather conditions. The dust must be applied when the plants are covered with dew and hot sun should follow. The method is unreliable and may be dangerous if the dust is inhaled.

Chemicals Employed—The following are most commonly used : —

Copper Sulphate : A 3-5 per cent. solution applied at the rate of 100 gallons per acre is usually effective in destroying common charlock and certain annual weeds. Success depends upon dry weather and there is often difficulty in dissolving the crystals.

Copper Chloride : This is more potent and more readily soluble than copper sulphate and is quicker in action. The usual concentration is 1–3 per cent. at 100 gallons per acre.

Sulphuric Acid : This is used in the unpurified form and is known as B.O.V. (Brown Oil of Vitriol). It contains 77 per cent. of sulphuric acid. The usual application per acre for weed control is 7 gallons of B.O.V. diluted in water to 100 gallons. Sulphuric acid damages sprayers even though they are lead lined, is dangerous to handle and ample and adequate protection is essential. **The acid must always be added to the water and not the water to the acid.**

Dinitro-ortho-cresol (D.N.O.C.) and dinitro-2-butyl-phenol (D.N.B.P.) destroy a wider range of weeds and many resistant species such as smooth leaved charlock, scentless mayweed and knotgrass can be controlled. D.N.B.P. has proved promising in the control of annual weeds in peas and lucerne. Both substances are toxic to animal life and highly poisonous to man and great care must be exercised in their use. Only a small margin of safety exists between the quantity of these chemicals required to kill weeds and that which injures the crop. Hence makers' instructions should be closely followed and expert advice sought.

"Hormone" weed-killers: The term "hormone" weed killer is in the strict sense incorrect, but it is convenient and its use has become customary. The materials concerned are two synthetic growth promoting substances, 2-methyl-4-chlorophenoxy-acetic acid known as M.C.P.A., and 2 : 4 di-chlorophenoxy-acetic acid known as D.C.P.A. Their selective action on certain weeds is to stimulate growth at such a rate that the plant is destroyed.

The range of weeds affected is not so great as with D.N.O.C. but there are certain advantages in that they are non-poisonous to animal life, non-corrosive and non-inflammable. The only real danger is that drift of these materials, as spray or dust, on to adjoining crops which are sensitive may be disastrous. The chief advantage is that they can be applied as dusts, sown through the ordinary fertiliser drill. One form is available as an oil emulsion.

Diesel Oils: In America, diesel oils have given good results as selective weed killers in such crops as carrots. Trials in this country have been disappointing but this may be due to climatic conditions or to the oil being too refined.

Spreaders: Some spray solutions possess a high surface tension and do not wet the leaves of weeds properly, tending to form into large drops. Sometimes the leaf surface is responsible. In such cases the addition of a spreader is necessary. Proprietary spreaders are on the market, such chemicals as sodium lauryl sulphate or sodium oleyl sulphate being commonly used.

Weed Burners—Oil-burning flame guns are used widely to-day, but their use on farm land is limited by the fact that they are very slow in action. Despite the intense heat they do not destroy weeds with underground parts.

COMMON BRITISH WEEDS OF FARM LAND

ANNUAL MEADOW GRASS (*Poa annua*). Poverty Grass.

This grass is a very common weed of arable land, overgrazed pastures, market gardens and waste land. It has the faculty of reaching maturity and shedding seed within a few weeks of germination and it reproduces during winter. It gains a strong root hold and may grow into large tufts. Hoeing or smothering with tall dense crops are the only remedies.

BARTSIA RED (*Bartsia odontites*).

Found in pastures, usually on chalky soils. It is a partial parasite on grasses. Raising of the general level of fertility suppresses this weed.

Bedstraw-Heath (*Galium saxatile*).

A weed of poor dry sheep pastures, heaths and lawns. It is an indication of low soil fertility and should be treated accordingly.

Bent, Common (*Agrostis tenuis Sibth ; Agrostis vulgaris With*).

Commoner in pastures than on arable land. In the former case it yields to general pasture improvement. For treatment on arable land, see " Twitch."

Bent, Creeping (*Agrostis stolonifera var. Agrostis alba*). Watergrass.

Found on arable land, chiefly in wet places. See " Twitch."

Bindweed, Black (*Polygonum convolvulus*). Bindweed, Corn (*Convolvulus arvensis*). Bindweed, Large (*Calystegia sepium*).

Black and corn bindweed are not as a rule of serious consequence in Great Britain. They occur in arable land, chiefly in cereal crops. Large bindweed infests garden shrubberies and hedgerows.

In arable land one can only use the usual cultural methods of control for runner bearing weeds. In bad cases, bare fallowing with continuous ploughing is a good remedy.

Bishop's Weed (*Aegopodium podagraria*). Goutweed, Ground Elder.

This is a very obstinate weed in gardens and orchards but rarely gives trouble on farm land. Constant hoeing or forking out ultimately destroys it. On uncultivated land it may be destroyed sometimes by a dressing of salt at the rate of 15 cwt. per acre, applied in March, preferably in dry weather.

Bracken (*Pteris aquilina*).

Bracken is on the increase throughout the country, though it is confined mainly to hill and moorland or to woods. Apart from occupying grazing land it provides cover for fly-blown sheep.

So far, the only remedy has been constant cutting or bruising over a period of years. Bracken cutting or bruising machines are available. The method of applying sodium chlorate to the stumps, while cutting, has shown promise. Another suggestion is the consolidation of the ground by heavy implements while the soil is wet and soft.

Broom Rape (*Orobanche major*).

A parasitic plant which is occasionally troublesome in clover. Other species attack other plants. There is no method of control once infection has occurred, but there are regulations prohibiting the sale of infected farm seeds.

Bryony, Black (*Tamus communis*). **Bryony, White** (*Bryonia dioica*).

Both black and white bryony, though unrelated species, are weeds of the hedgerows. They are alleged to be poisonous to livestock. It is a good plan to pull them out of the hedges of pasture fields, particularly where young animals graze.

BURNET, GREAT (*Poterium officinale. A. Gray Sanguisorba officinalis L.*). BURNET, LESSER (*Poterium sanguisorba*).

The former weed is found in wet meadows in a low state of fertility and the remedy is obvious. It should not be confused with the latter species which is a plant of calcareous pastures and has a definite value for grazing.

There is also a foreign species known as the fodder burnet (*Poterium polygamum*). It is occasionally found in waste places.

BUTTERCUP, UPRIGHT (*Ranunculus acris*). BUTTERCUP, BULBOUS (*Ranunculus bulbosus*). BUTTERCUP, CORN (*Ranunculus arvensis*). BUTTERCUP, CREEPING (*Ranunculus repens*).

The upright bulbous and creeping buttercups are found in pastures. They are all comparatively short-lived perennials and die out if they are not permitted to flower for a few years. It is for this reason that they are most frequent on fields where grazing commences comparatively late in the season after flowering. This also explains their abundance on wet pastures. The best treatment is to graze early or top off the flowers. The general fertility should be raised.

Buttercups waste space in a pasture as they are not grazed. They are commonly believed to be poisonous, but this is lacking proof since they are so abundant in many pastures that poisoning cases would be more frequent if this were the case.

Creeping buttercup occurs on arable land and should be treated like other runner-bearing weeds. The plants are fairly easy to drag out with harrows as the runners are superficial, but sometimes the plants are held in the clods in stiff soil.

Corn buttercup may be treated as an annual weed. Treatment with the "hormone" weed killers is very effective. The species occurring in pastures also appear to yield to this treatment.

CAMPION, WHITE (*Lychnis alba*).

This plant is a biennial and occurs in crops of lucerne and in two-year leys that are mown. These crops offer undisturbed conditions for two years. The only possibility of control is by harrowing out the seedlings.

CARROT, WILD (*Daucus carota*).

This is a biennial occurring along with white campion. The same rules apply for its control.

CATSEAR (*Hypochaeris radicata*).

This weed is common in lawns and on poor sheep pastures where the land is closely grazed. A general improvement of fertility is the only remedy.

Chamomile, Corn (*Anthemis arvensis*). **Chamomile, Rayless** (*Matricaria suaveolens*). **Chamomile, Wild** (*Matricaria chamomilla*).

These are all annual weeds of arable land and may be destroyed while in the seedling stage. They are resistant to all weed killers except D.N.O.C. Rayless chamomile is more confined to headlands, gateways and hard trodden areas.

Charlock (*Brassica arvensis*). **Kedlock, Yare, Yellows.**

This is the commonest annual weed in cereals especially on light soils and in spring sown crops. The seed may lie dormant for very long periods and a heavy infestation may occur after the ploughing of an old pasture.

Early harrowing may destroy vast numbers of seedlings and the cultivation of root crops for two years in succession on a field reduces the infestation greatly.

Charlock is sensitive to copper sulphate, sulphuric acid and D.N.O.C. sprays. The latest and most effective treatment is to sow 2 cwt. per acre of one of the " hormone " weed killers in powder form. It is a host for club-root and other diseases of cruciferous crops. So also is smooth-leaved charlock, wild radish and shepherd's purse.

Charlock, Waxy or Smooth Leaved (*Brassica campestris*) **Wild Rape.**

This weed is an annual and is only distinguishable from charlock by its waxy leaves and stems and the fact that the base of the leaf encircles the stem. It may be destroyed in the same way as charlock, by cultivations. It is undamaged by copper sulphate or sulphuric acid, but yields to D.N.O.C. and the " hormone " weed-killers.

Cleavers (*Galium aparine*). **Goosegrass, Herrif.**

This is an annual weed with long trailing and sticky stems that adhere to the clothing. Seeds may also be carried on clothing and on animals bodies. It is common in corn crops particularly in the Eastern Counties.

Seedlings may be destroyed by surface cultivation and the more mature plants are sensitive to D.N.O.C.

Cockle, Corn (*Lychnis githago*).

An annual weed of cereal crops, the seed of which is poisonous. As corn cockle grows to a height of 3–4 ft., it can offer serious competition as an annual weed

Chickweed (*Stellaria media*).

A very common annual weed in arable land and gardens. It seeds profusely, but is suppressed by growing crops. It may be a nuisance in bulb crops or in potatoes, before harvest. It can be killed by sulphuric acid and by the usual cultural treatments for annuals.

CORNFLOWER (*Centaurea cyanus*).

This weed is not of serious consequence. It occurs as an annual in cereal crops and should be treated as such.

COUCH (*Agropyron repens*). *Scutch, Squitch, Wicks.*

A tall coarse grass with fleshy sub-surface runners. See "Twitch."

CRANESBILLS (*Geranium ssp. Erodium ssp.*).

Annual weeds of low habit, found on light sandy arable land. They are not usually of major importance and should be treated as annual weeds.

CROWFOOT, CELERY LEAVED. (*Ranunculus sceleratus*).

This weed grows round ponds and in wet hollows. It is sometimes eaten by cattle, especially in times of drought, and has caused deaths. The plants, which are not usually numerous, should be cut down.

DAISY, COMMON (*Bellis perennis*).

A weed of lawns and heavily grazed pastures. It occupies grazing ground in the latter case. The "hormone" weed killers are effective on lawns. In pastures, a raising of the general fertility combined with setting up for hay or less intense grazing, suppresses this weed.

DAISY, OX-EYE (*Chrysanthemum leucanthemum*). DOG DAISY, MOON DAISY.

Occurs on land in a low state of fertility, particularly hill pastures. Raising of the general fertility proves effective in eradication.

DANDELION (*Taraxacum officinale*).

This weed is common at roadsides, in gardens and on waste land. Sometimes it may assume serious proportions in new leys and so affect production. Complaints that dandelion causes bitter milk, lack support.

The sudden increase of dandelions in a field may be due to heavy seed infestation, but it may be due also to the breaking up of the roots by drastic cultivations, the dandelion being propagated from root cuttings. This weed will not survive arable cultivations.

DEAD NETTLE (*Lamium album*).

Dead nettle is always associated with colonies of stinging nettle although it is a different species. For control measures, see "Nettle, Great Stinging."

DOCK, BROAD LEAVED (*Rumex obtusifolius*). DOCK, CURLED (*Rumex crispus*).

Docks are common and extremely unsightly perennial weeds. The two chief species affecting agriculture are the Broad Leaved and Curled Dock. Propagation is by seed and is also vegetative, by shoots arising from the crown and growing as separate plants. Seedling docks may be worked out of the soil, but it is usually necessary to hand pick them. Mature docks should be prised out of the ground with a docking tool. If they are cut or broken off about 3 inches below the soil surface, the remaining roots will not produce shoots.

Dodder. Clover (*Cuscuta trifolii*).

A parasitic weed attacking clover. The only effective control is by using clean seed. Under the "Seeds Regulations, 1922," a statement must be made by the vendor if more than a specified minimum of dodder seed is present in clovers.

Fat Hen (*Chenopodium album*). **Goosefoot, Muck Weed, John-o-Nails.**

A common annual weed of arable land, especially round manure heaps.

There are several closely related species and hybrids (see also "Orache"). This weed should be controlled by surface cultivation and hoeing. It is sensitive to D.N.O.C.

Foxglove (*Digitalis purpurea*).

A weed of hedgerows and felled woodland, on acid soils. Foxglove is poisonous and contains the drug digitalin which affects the heart. Authentic cases of poisoning are lacking, but if doubt exists it can be cut down or pulled out by the roots.

Foxtail, Creeping (*Alopecurus agrestis*).

An annual grass that seeds heavily and is a serious nuisance in arable land in some parts of England. The seed is viable only for a year or two so that it is possible to control the weed by stubble cleaning.

Fumitory (*Fumaria officinalis*).

An annual weed of arable land. Controlled by the usual cultural methods. Sensitive to D.N.O.C.

Groundsel (*Senecio vulgaris*).

A very common annual weed of arable land and gardens. Controlled by the usual cultural methods.

Hawksbeard (*Crepis virens*). **Hawksbit** (*Leontodon autumnalis*). **Hawksweed** (*Hieraceum pilosella*).

These are all perennial weeds of somewhat similar appearance. They are often regarded by laymen as species of dandelion. They are found on dry waste ground and poor pastures. Raising of the general level of fertility is the only method of suppressing these weeds in pastures.

Hemlock (*Conium maculatum*).

A tall umbelliferous biennial. Other species are often confused with hemlock but it may be distinguished by purple spots on the stem and the mousy smell of the fruits. Hemlock contains well-known poisonous principles, but it is only likely to be eaten during drought.

Hemp-Nettle (*Galeopsis tetrachit*).

An annual weed of arable land. It may be destroyed by cultural means and is very sensitive to D.N.O.C., " Hormone " weed-killers and to sulphuric acid.

HORSETAILS (*Equisetum ssp.*). MARES-TAILS. TOAD PIPES.

There is a number of species that are often difficult to distinguish. Common Horsetail is a weed of arable land and of embankments. Marsh Horsetail and Great Horsetail occur in pastures and are poisonous. Horsetails are difficult to eradicate as the reason for their presence is not well understood. They are found on sites where drainage is impeded, but they may grow on very dry land or on embankments.

KNAPWEED (*Centaurea nigra*).

Occurs in meadows usually in association with Burnet, and like that plant indicates a low state of fertility.

KNOTGRASS (*Polygonum aviculare*). WIRE WEED. PIG WEED.

A creeping annual with wiry stems. Is found on waste land and in stubbles and is common in pig pens. Is suppressed by taller plants.

MADDER, FIELD (*Sherardia arvensis*).

An annual weed of arable land. Controlled by the usual cultural methods.

MAYWEED, SCENTLESS (*Matricaria inodora*).

A serious annual weed of arable land. It is particularly prevalent on heavy soils and is most abundant in wet seasons. As it seeds profusely, stubble cleaning may destroy many seedlings. The usual cultural methods may be employed in spring. When the plant has developed and before flowering, it will yield to D.N.O.C.

MAYWEED, STINKING (*Anthemis cotula*).

Somewhat similar in appearance to Scentless Mayweed. The same advice applies as to eradication.

MEADOW SAFFRON (*Colchicum autumnale*). AUTUMN CROCUS. NAKED LADIES.

A bulbous perennial weed like a crocus and found growing in damp meadows. It is alleged to have poisoned cattle and contains the drug colchicine.

MIGNONETTE (*Reseda lutea*).

A biennial weed of chalky soils and very common in lucerne crops. It may be reduced by harrowing out the seedlings in the first season of growth.

NETTLE, ANNUAL (*Urtica urens*).

A small annual species, found on arable land and market gardens, where the soil is in high condition. It is common also on sewage farms. Cultural methods of control as for other annuals, reduce the numbers.

NETTLE, GREAT STINGING (*Urtica dioica*).

A well-known perennial weed, spreading by runners. It is favoured in its spread and is dependent upon a light surface cover of litter. It is its association with rubbish heaps that suggests neglect when nettles are abundant.

It may be prevented by removing surface litter. This weed is very sensitive to sodium chlorate and also to dressings of common salt at the rate of 10–20 cwt. per acre, if applied in March. In fields, it may be eradicated by the treading of cattle which may be effected by placing a feeding trough or a lump of rock-salt in the middle of the patch.

Nightshade, Black (*Solanum nigrum*). **Nightshade, Deadly** (*Atropa belladonna*). **Nightshade, Woody** (*Solanum dulcamara*).

The Black Nightshade is an annual weed of arable land and is most common in mangel and sugar beet crops. It gives little trouble and although possessing poisonous properties it is not likely to be eaten by stock.

Deadly Nightshade is a handsome perennial, occurring on stone heaps or about old ruins. Such situations are hardly likely to be grazed by stock and poisoning is thus unlikely.

Woody Nightshade is the common woody climber of the hedgerows and is usually and erroneously called deadly nightshade. This plant grows on dry land or even with its roots submerged. It should be pulled out of the hedges as a precaution.

Oat, Wild (*Avena fatua*).

Wild Oats are presenting a serious problem in cereal growing districts of East Anglia. They are structurally the same as other cereals and they are resistant to selective chemical treatment. The growing of root crops for two or three years in succession may reduce numbers. Great care should be taken that seed corn is free from them.

Onion Twitch (*Arrhenatherum avenacium var bulbosum*). See "Twitch."

Onion, Wild (*Allium vineale*).

A bulbous weed that gives trouble in arable and pasture land in certain parts of England. It has a very complex system of reproduction making it very persistent and is also resistant to chemical treatment.

A rotation based on the principle of six spring-sown crops in succession has been devised by J. R. Tinney, an Essex farmer, to eradicate this weed. He also lays down seven "golden rules" as follows :—

(i) Never pull onions.
(ii) Never introduce a bare fallow.
(iii) Never plough in September or October.
(iv) Never sow winter cereals or winter beans.
(v) Never sow clover or seeds mixtures for short or long leys, or sainfoin or lucerne alone or in mixtures.

(vi) Never attempt to eliminate wild onions on wet land until it is drained.

(vii) Never assume the absence of wild onions, even if they cannot be seen, until the six years programme has been completed.

ORACHE (*Atriplex patula*).

Somewhat like Fat-Hen in appearance but sprawling in habit. It yields to the same treatment as Fat-Hen.

PARSLEY POERT (*Alchemilla arvensis*).

An annual weed usually found in association with the cranesbills and should be treated in the same manner.

PENNYCRESS (*Thlaspi arvense*).

An annual weed of arable land and gardens. The same cultural treatment may be followed as for other annuals. It is sensitive to all the usual chemical weed-killers.

PEPPERWORT, HOARY (*Lepidium draba*). HOARY CRESS, THANET WEED, CHALK WEED.

This weed is a perennial with a dense system of underground runners. It seeds profusely and thus has two methods of propagation.

It is difficult to destroy the runners by cultivation as they are so brittle, but they may be weakened by constant cutting down of the aerial parts. The latter may be burnt off by corrosive sprays. Seedlings may be destroyed by cultural means.

PIGNUT (*Conopodium majus*).

A tuberous perennial found in poor pastures. The tubers are edible. This weed may be a nuisance for a year or two after ploughing an infested pasture, but it succumbs to disturbance. It becomes suppressed if the general fertility of the land is raised.

PLANTAIN, BROAD LEAVED (*Plantago major*).

A weed of gateways and badly poached leys. It is rapidly suppressed by taller vegetation if grazing becomes less intense or if soil fertility is raised.

PLANTAIN, NARROW LEAVED (*Plantago lanceolata*). RIBGRASS

This plant occurs in closely grazed sheep pastures. Its status as a weed is questionable as it is sometimes sown for grazing.

POPPY (*Papaver rhoeas*).

A common annual weed in cereal crops particularly chalky soils. It may be treated in cultivations as an annual weed. It is sensitive to D.N.O.C. and fairly sensitive to the " hormone " weed killers.

RADISH, WILD (*Raphanus raphanistrum*). WHITE CHARLOCK. RUNCH.

This weed may be distinguished from charlock by its white flower, jointed seed pod and tougher leaf. In the early stages of growth it is indistinguishable from charlock.

Treatment is the same as for charlock, except that it does not yield to copper sulphate spray.

Pieces of the seed pods, each containing a seed may be present in seed corn as it is difficult to separate because of similarity of shape and size.

Ragwort (*Senecio jacobaea*).

A well-known perennial weed of poor pastures. It occupies grazing ground and is poisonous to cattle. Sheep may graze it with impunity in the early stages, but the poison is said to be cumulative and cases of poisoning in sheep are reported from abroad.

The best remedies are systematic cutting or pulling to prevent seeding and weaken the rootstock, raising of soil fertility and grazing by sheep while the plants are young.

Ransoms (*Allium ursinum*).

A weed of woodlands. The whole plant has a strong onion flavour and is a cause of taints in milk. Cattle should be fenced off and the plants cut down.

Rattle, Yellow (*Rhinanthus-crista-galli*).

This weed is partially parasitic on grasses and occurs in poor pastures and meadows. Tends to disappear with manuring.

Redshank (*Polygonum persicaria*).

A common annual weed in arable land occurring in wet districts, where the water table is high or where there is impedance of water.

It may be treated as an annual weed after proper drainage has been effected.

Rush, Common (*Juncus communis*). Rush, Jointed (*Juncus articulatus*).

Rushes occur on badly drained land or where a wet surface allows seedlings to become established. Rushes may be eradicated by cutting, together with a liberal application of basic slag and the encouragement of a thick sward of grass.

Shepherd's Needle (*Scandix pecten-veneris*). Venus Comb.

An annual weed of arable land. It should be treated culturally as for other annuals, but it is sensitive to the " hormone " weed-killers.

Shepherd's Purse (*Capsella-bursa-pastoris*).

An annual weed of arable land and gardens. Cultural treatment as for other annuals.

Sorrel, Sheep's (*Rumex acetosella*).

This is the most reliable indicator of acid land. It is a perennial and may take a few years to die out, but it always succumbs to liming.

SORREL, BROAD LEAVED (*Rumex acetosa*).

This weed is often confused with sheep's sorrel (see "Indicator Weeds"). It is common on phosphate deficient pastures and disappears after the appropriate manuring.

SOW THISTLE (*Sonchus oleraceus*).

An annual weed of arable land and gardens. It is controlled by the usual cultural operations.

SOW THISTLE, CORN (*Sonchus arvensis*).

A perennial weed fairly common in cereal crops. It is eradicated easily by cultivations.

SPEEDWELLS (*Veronica ssp.*).

Common annual weeds found in association with chickweed and groundsel. They should be treated in the same manner.

SPURGES (*Euphorbia ssp.*).

Annual weeds found in gardens and arable land. They should be treated as other common annuals.

THISTLE, CREEPING (*Cirsium arvense*). FIELD THISTLE.

This well-known thistle is a perennial with deep seated underground runners by which it spreads. The seed has a low rate of germination and the distribution mechanism of the plant is faulty. For all practical purposes, spread by seed may be discounted. Removal of grass competition on the surface causes numerous shoots to spring from the runners below and these shoots are often mistaken for seedlings.

Thistles waste valuable grazing and even the cut stumps cause sheep to avoid the ground.

The only effective means of control is by systematic cutting twice yearly, usually in June and September.

The shoots of thistles in cereal crops may be burnt off by sulphuric acid spraying and this prevents a painful nuisance at harvest time.

THISTLE, MARSH (*Cirsium palustre*).

This thistle is a perennial found on marshy ground where it may be as abundant as creeping thistle. It is taller and more slender than the latter. Systematic cutting is the only remedy.

THISTLE, MUSK (*Carduus nutans*).

A biennial thistle common on chalky pastures and in crops of lucerne. Spudding in the first season is the only method of control. It is not so widespread in fields as creeping thistle and the colonies are less dense.

THISTLE, SPEAR (*Cirsium lanceolatum*).

A biennial thistle common in pastures. It is not usually a serious weed but it is unsightly. Spudding is the best means of eradication.

THISTLE, STEMLESS (*Cirsium acaule*).

This thistle is common on poor chalky down-land and forming compact rosettes cannot be cut. It is usually too numerous for spudding. Raising of the general level of fertility or ploughing and reseeding are the only remedial measures possible.

"Twitch."

This heading is a convenient one to cover a group of runner bearing grasses, the control measures for which are similar. The group includes Creeping Bent, Common Bent, Woolly Soft Grass and Couch. The last-named is, however, more prevalent in gardens. In addition one may include Onion Twitch, a bulbous variety of Tall Oat Grass. The control of the latter demands special consideration.

All these grasses produce fertile seed but propagation is mainly vegetative. The hedge bank is their natural habitat or similar protected sites. The commonest method of distribution over a cultivated field is by implements which pick up pieces of runners from the headlands and carry them out on to the field.

Control is best effected by ploughing, cultivating or, in some cases, summer fallowing. (See "Control by Cultivation.")

Onion Twitch presents a special problem and sometimes spreads beyond control, making it necessary to sow the land down to grass. It cannot tolerate grazing and treading.

The only method of controlling this weed is the harrowing of the bulbs to the surface and then hand picking or raking.

Vetches, Wild (*Vicia ssp.*).

These weeds may be a nuisance in cereal crops as they may entangle and pull down the crop. Harrowing out seedlings is the only cultural method of control.

Viper's Bugloss (*Echium vulgare*).

A biennial found on sandy and chalky soils. It is very common in lucerne. The plants should be destroyed by spudding.

Willow Herb (*Epilobium augustifolium*).

A perennial, runner bearing weed that seeds profusely. It is sometimes troublesome for a few years on newly reclaimed land. Seedlings cannot tolerate competition, hence its appearance after fires. It succumbs rapidly to cultivation.

Woodrush (*Luzula ssp.*).

There are several species of this weed. It occurs on poor phosphate-deficient pastures and on very acid soils.

POISONOUS WEEDS

Weeds alleged to be poisonous and others, where definite proof of their poisonous properties has been obtained, are listed above. There are, in addition, trees such as the yew, that cannot be classed as weeds. Rhododendrons have given trouble and in these days when many new shrubs are introduced from abroad there is an ever present danger in urban areas, where gardens adjoin farm land.

It is very difficult to obtain really authentic cases of poisoning by weeds, and there is no doubt that deaths due to deficiency diseases were at one time ascribed to some weed. It is rarely impossible to find a weed in a pasture or hedgerow that has not at some time been alleged to be poisonous.

It often happens that animals consume large quantities of a poisonous weed without ill effects. Many factors influence the action of the poison and much depends on the age and size of the animal. Poisons are more effective in an empty stomach. Plants may be poisonous at a certain stage of growth, whilst some parts only of a plant may contain a poison. A common example is the potato where the tubers are edible and the stems mildly poisonous.

The presence of large quantities of a weed in the stomach of an animal that has died suddenly, is not proof that the weed is the cause of death. The disease responsible may have caused a morbid appetite and the animal may have eaten the weed in an attempt to satisfy a craving or to alleviate pain.

Young animals, particularly lambs, often eat and die from the effects of a poisonous weed because they have acquired a morbid appetite due to parasitic infestation.

In dry weather, when pastures are burnt up, cattle may forage round ponds and wet places and thus graze weeds like celery-leaved crowfoot or marsh horsetail. On new leys they often search for other herbage, probably to satisfy a craving for variety or more fibrous food. In this way they may consume poisonous plants and recent cases of bracken poisoning may have been of this type.

It is a good plan to go round the hedgerows and remove any plants of woody nightshade or bryonies, especially where young animals graze. In dry seasons it is advisable to scythe round ponds.

When death occurs in livestock without apparent cause, all possibilities should be investigated and the presence of poisonous weeds not accepted too readily as an explanation.

INDICATOR WEEDS

It is a very common belief amongst farmers that the presence of a certain weed or group of weeds indicates some particular soil condition, usually a deficiency of some chemical element. In actual fact it is only when a weed is found in large proportions that its presence has any significance and even then it may only mean that a large quantity of seed has chanced to fall there. However unfavourable the conditions may be for a plant, if there is sufficient seed, some individuals may establish themselves and survive for a few years.

It has been stated that redshank, rushes, marsh thistle and marsh horsetail are reliable indicators of wet conditions.

Except in the case of redshank, the wet state of the soil is usually obvious without the guidance of the weeds. Rushes may, however, be present in comparatively dry soil, provided the surface is wet at the time when the seed germinates.

Nettles indicate that some loose material has lain on the surface and allowed them to proliferate. They do not necessarily indicate a high nitrogen content of the soil. This does not refer to the small annual nettle, a weed of market gardens and highly farmed land.

Some weeds, such as the stemless thistle, wild mignonette and tor grass, are only found on chalky soils. They are known as calcicoles and are very acid sensitive.

The weeds that indicate an acid soil are known as calcifuges. Common example are sheep's sorrel, spurrey, corn marigold and foxglove. It is important to remember that it is sheep's sorrel (*Rumex acetosella*) that indicates acidity and not the broad-leaved sorrel (*Rumex acetosa*). The former may be distinguished by the fact that the " ears " at the base of the leaves stick out at right angles, and the surface of the leaf is dull. In the latter the " ears " recede and the surface is shiny. The broad-leaved sorrel is a fairly reliable indication of phosphate deficiency.

FOREIGN WEEDS

In the past, our exports carried British weeds to all parts of the world. Many established themselves and became a nuisance. To-day the position is reversed and foreign weeds invade this country. Very few survive our climate, but there are a few notable exceptions. The rayless chamomile (*Matricaria suaveolens*) has spread over the whole country since the beginning of this century.

Galinsoga parviflora, a South American native, has become established in parts of the Eastern counties.

Lately a weed that is a host of potato diseases, *Solanum sarachoides*, has arrived in carrot seed of Californian origin and has become established in some districts.

The disastrous spread of Canadian pondweed (*Elodea canadensis*) is well known and indicates that a weed new to this country should be controlled. Doubtful specimens may be identified, free of charge, if sent, suitably packed, to the Director, Royal Botanic Gardens, Kew, Surrey.

THE INJURIOUS WEEDS ORDER, 1921

Prior to the 1939-45 war, county councils were responsible for the administration of the Injurious Weeds Order, 1921, on behalf of the Ministry of Agriculture and Fisheries.

Spear thistle, creeping or field thistle, curled dock, broad-leaved dock and ragwort were scheduled as injurious weeds.

During the 1939-45 war, it became the responsibility of county war agricultural executive committees to ensure the destruction of weeds. Under the Defence of the Realm Act they used their powers to order the destruction of weeds, other than those scheduled under the 1921 Order.

Under the Agriculture Act, 1947, where the Order is concerned with agricultural land, its administration will be the responsibility of the County Agricultural Executive Committee. To the weeds scheduled under the Order may be added such injurious weeds as the Ministry may, by regulations under this section, prescribe, and such regulations may make different provisions in different cases specified in the regulations.

Where a notice has been served under the order on the occupier of any land requiring him to cut down or destroy weeds, and that person unreasonably fails to comply with the requirements of the notice, he shall be liable, on summary conviction, to a fine not exceeding £20, and to a further fine, not exceeding £1, for every day during which the default continues after conviction.

FARM LIVESTOCK

BREEDING OF CATTLE

DAIRY BREEDS—Ayrshire, British Friesian, Guernsey, Jersey, Kerry.

BEEF BREEDS—Aberdeen Angus, Devon, Hereford, Galloway, Sussex, Highland, Shorthorn, Belted Galloway.

DUAL PURPOSE—Red Poll, Lincoln Red Shorthorn, South Devon, Dexter, Welsh Black, Shorthorn, Blue Albion.

BREEDS OF LESSER NUMERICAL IMPORTANCE—White Park or British White, Longhorn, Orkney, Shetland, Gloucester.

Ayrshire—The Ayrshire Cattle Herd Book Society was established in 1877 and the first Herd Book published in 1878. The numbers of cattle of this breed have increased steadily; in 1931 the membership was 731, in 1949 it was 4,175. The colour is red or brown with a varying amount of white. A large proportion of white is at present the fashion. Black and white though not uncommon is not popular. The upward curve of the horns is very characteristic.

The breed is famous for its well-marked "dairy" wedge conformation and for the length and width and firmness of attachment of the udder. In the past the teats were often too small but this fault has now been bred out.

The breed has a high percentage of attested herds and there is always a good supply of stock for sale that are free from tuberculosis. Milk yields are good and fat percentage satisfactory. The fat globules are small and thus the milk is suited to cheesemaking. The breed has little value as a meat producer. There is a grading-up scheme.

British Friesian—The breed takes its name from the province of Friesland in Holland. In the 18th and 19th century many black and white cattle were imported from Holland. In 1892 these importations ceased compulsorily and as a result, breed type became somewhat impaired. The British Friesian Cattle Society, founded in 1909, arranged importations of cattle in 1914, 1936 and 1938 from Holland, in 1922 from South Africa and more recently from Canada. These importations had very considerable influence on the breed. The colours are black and white with white switch and feet. The horns are small and curve forwards and inwards. The cattle are large being exceeded in size only by the Lincoln Red Shorthorn and South Devon. The numbers have increased rapidly of recent years. The average yield of milk is high but the fat content is normally lower than the other dairy breeds. Careful selective breeding can do much to increase the average fat percentage of a herd. Fat globules are small, thus the milk travels well and is suitable for cheesemaking. The calves are suitable for veal. There is a grading-up scheme.

Guernsey—This breed originated as a blending of two breeds of French cattle, the "Froment de Leon" of Brittany and the "Isigny" of Normandy. It includes the cattle on the islands of Guernsey, Alderney, Sark and Herm.

It is larger and rather heavier in bone than the Jersey and is not, as many think, delicate. It is rather slower to mature than the Jersey and like it is of no importance as a meat producer, although Guernsey calves are sometimes sold as veal.

The milk of the Guernsey is rich in butter fat and the globules of fat are large in size.

In colour the cattle are various shades of fawn, yellow, red, brown. White markings may or may not be present. Dark noses are not infrequent but a light or buff coloured muzzle is preferred. The skin is strongly pigmented with yellow. There are two Herd Books, the Island and English. The English Guernsey Cattle Society was formed in 1884. There is a grading-up scheme.

Jersey—This breed of French origin has lived on the island for hundreds of years. No foreign blood has been allowed into the island since 1763. It was in 1844 that Channel Island Cattle first had classes at the Royal Show whilst in 1862 Jerseys and Guernseys were put into separate classes.

The Island Herd Book was established in 1866. The English Jersey Cattle Society was founded in 1878 and the Herd Book first published in 1879.

It is a small breed, reaching maturity early, producing good yields of milk very rich in butter fat with large fat globules. The quality of bone, skin and horn is very fine and colours are various shade of fawn, mulberry, broken fawn and white, mulberry and white, silver. A characteristic marking is the white mealy ring round the nose. Like the Guernsey the breed is of no account as a meat producer. The breed acclimatises rapidly and the Jersey is by no means a delicate creature. There is a grading-up scheme.

Kerry—A very ancient breed, small in stature, black in colour though frequently with some white on the udder. In the western areas of Eire it is supreme and only Kerry bulls are licensed for use in those districts. Relatively unimproved as compared with some other breeds the British Kerry Society resolved in 1936 to register only bulls from cows that had yielded at least 800 gallons in 52 weeks. It is perhaps surprising that the breed remains numerically so small.

Aberdeen Angus—Originated in north-east and central Scotland. The Doddie as it is called is coloured black. There may be a little white on the underline behind the navel. It is polled.

In size it is exceeded by the Shorthorn, Hereford and Sussex. Being fine in bone, compact and short of leg it rarely looks its weight. It is early maturing producing meat of excellent quality and is well suited for intensive feeding and marketing as baby beef. Under poor ranging conditions it is hardly as good as the Hereford. It is often used for crossing with cows of dual purpose breeds to produce good commercial beef. The Angus cow mated to a White Shorthorn bull produces the **"Blue Grey" cross.**

The Herd Book, a closed register, was established in 1862.

Aberdeen Angus Stock have been exported in large numbers in particular to North America, the Argentine and New Zealand.

Devon—Has its origin in North Devon and are called "Red Rubies" because of their dark cherry red colour. The breed is horned. The cattle are hardy, good grazers, produce beef of good quality and in size are rather smaller than Sussex. The cattle of this breed are early maturing as results at the Smithfield Show have made clear. Within the breed there are several herds that have a milk producing ability typical of dual purpose cows yielding averages of 700 gallons per year. Of recent years the breed has increased in popularity in other parts of England and in Wales. The breed has been exported to numerous countries, such as North and South America, South Africa and Australia.

In 1850 Colonel Davy published the first volume of Davy's Devon Herd Book.

Hereford—Founded on a type of early maturing beef cattle in Hereford the breed in some respects is still rather local in Britain, the greatest number being found in those counties on both sides of the English and Welsh border.

The cattle are large, deep rich red in colour with white head and underline. There is a narrow white band extending along the upper part of the neck and over the crop. The beef quality is not quite so excellent as the Aberdeen Angus; the milking ability is usually poor but the breed combines in good measure, more so than any other breed, early maturity, good fattening quality and robust constitution and is noted for its ability to do well on grass. The Herd Book was established in 1846 and is a closed Register.

Large numbers of this breed have been exported especially to the U.S.A., Canada, South America and Australia. In the U.S.A. in 1943 there were three times as many pedigree Herefords recorded as all other beef breeds combined.

Galloway—For centuries Galloway Cattle have been bred in the south-west of Scotland and in Cumberland and Northumberland. In 1573 Ortelius wrote of their flesh as " tender, sweet and juicy."

They are very hardy and thrifty cattle able to thrive under conditions of poor keep and severe climate. The breed is naturally slow maturing but produces meat of excellent quality. In recent years many successes have been gained at the Smithfield Show. While they can be fattened on grass they fatten more readily in yards. It is, like the Aberdeen Angus, black and polled, with a thick skin and abundant coat. The cross with the White Shorthorn known as the " Blue Grey " is very popular though not so fast to mature as the Blue Grey from the Aberdeen Angus × Shorthorn mating.

The Galloway Cattle Society was formed in 1877 and the first volume of the Herd Book published in 1878.

Sussex—This breed originated on the heavy clays of the south-east counties and in earlier days was kept mainly for draught purposes, but as conditions changed so the breed developed its beef qualities. In size about the same as the Hereford it is rather less compact and rather later to mature. Steady improvement of the breed is being maintained in the direction of shorter legs, meatier shoulders and better hind quarters. The quality of meat is very good and animals of this breed are notable for their ability to thrive on poor fare. For grazing they are unique in their lack of discrimination and apparent liking for almost any grass, clover or weed. The colour is deep red and the horns are fairly large. The Herd Book was established in 1874. Sussex cattle have been exported to various countries and have been very successful in South Africa and Rhodesia.

Highland—Cattle of this breed are able to find a living on poor pastures in severe climate and high altitudes. They are naturally very hardy, exist where other cattle starve and though docile are rarely housed. They are slow to mature and normally will be 3-4 years of age before being ready for sale fat. The colour is dun, reddish brown or brindled and the animals carry massive horns and a shaggy coat of long wavy hair.

The cows if mated to a Shorthorn bull produce a quick growing steer. A common practice is to mate the first cross of this mating to a Shorthorn bull.

Highland cattle have been exported to several countries, including Russia, the Falkland Islands and Newfoundland.

The Beef Shorthorn—This breed has played a most important part in beef production in the north of England and Scotland. It is an early maturing breed producing beef at various ages and adaptable to fattening in yards or on grass. It is much used for crossing. Mated with the Galloway it produces the well-known "Blue Grey." It is also crossed with the Aberdeen Angus and with dairy and dual purpose cows to produce good commercial beef stores. Another favourite method of crossing is to use the Shorthorn bull on the Highland cow and the Shorthorn again on the first cross of this mating. It is widely adaptable and stamps its characteristics on poorer types. The colour may be red, roan, white, or red and white. The breed is horned.

The Beef Shorthorn has been exported in great numbers to Argentina, U.S.A., Canada, Australia and South Africa.

All Shorthorns both "Beef" and "Dairy" are registered in Coates Herd Book established in 1822. It is an open register, that is, animals may be graded-up into the Herd Book.

Belted Galloway—There have been cattle of this breed in southern Scotland and certain northern counties of England for centuries. They are hardy, able to thrive in severe conditions. In their native areas they are slow to mature but improve in this respect when taken to better conditions.

The appearance is distinctive being black with a brownish tinge and a white belt or dun with the same marking. The belt lies between the shoulder and the hooks. The breed is hornless.

Lincoln Red Shorthorn—This breed is a strain or offshoot of the Shorthorn breed being descended from the same Teeswater blood. Like the Shorthorn there are distinct beef and dual purpose strains and the Herd Book of the Society is composed of two sections—one for qualified dairy animals, the other for beef herds.

As a breed they are able to thrive under bleak conditions and modest fare. They are not very early to mature and cannot be fattened at young ages. Dairy type Lincoln Reds do not produce phenomenal yields but averages of 700-800 gallons are common.

Cattle of this breed are a deep rich red colour and are horned. Though not confined to their name county they are found chiefly in Lincolnshire and Nottinghamshire and parts of adjoining counties.

The Red Poll—The breed was developed in the south-east of England, in East Anglia and parts of Suffolk and Norfolk. Developed under conditions of only moderate quality food they tend, if removed to conditions of plenty, to become rather coarser in bone and larger in size.

An early maturing breed, in size it equals the Aberdeen Angus and is able to produce excellent baby beef. They were in fact the first stock fattened into baby beef.

Milk production figures are impressive as the tables show.

Considerable progress is being made in the breed towards uniformity of type whilst longevity is a characteristic of the breed.

The breed has been exported to several countries of which, at the present time, South Africa and Australia are the most important.

The R.A.S.E. recognised the breed in 1862. The Herd Book was started in 1874. The Red Poll Society incorporated in 1888. There is a grading-up scheme.

South Devon—The colour varies from light brown and fawn to a deep reddish brown. The darker colour is more popular and is described as medium red. This is the largest of British breeds cows frequently weighing 14 cwt. Certain types of South Devon are rather coarse of bone and skin and produce joints of large size, the udders being rather pendulous and the teats sometimes very large. Breeders are now concentrating on a rather shorter legged type with finer bone and more shapely udders and teats.

The breed is not quick to mature and like the Lincoln Red does not fatten at young ages though live weight gains from birth are good.

The breed produces milk rich in fat and high yields are common. There is a steady trade in steers to be fattened on grassland in the Midland Counties and in the south-east.

Cattle of this breed have been exported to various countries.

The Herd Book was started in 1891. There is a grading-up scheme.

Dexter—This is the smallest breed of cattle in the British Isles. In colour the cattle are whole black or whole red and are horned. In relation to their size the barrels are large and legs small. They are not early to mature, but produce good quality meat. Crossed for example with the Aberdeen Angus or Shorthorn produces a good small beef beast. They are heavy milkers in relation to their size but carry rather pendulous udders that may make actual milking difficult.

Imperfect or monstrous calves are more common with this breed than others. In the Kerry breed from which the Dexter was formed a mutation arose causing inhibition of the length growth in the bones thus producing the bulldog calf. These calves die and are aborted. This mutation is only lethal in the homozygous condition and bulldog calves can be avoided by mating short legged cows with long legged bulls or vice versa. If two short legged beasts are mated a bulldog calf can result.

The Welsh Black—Formerly two breeds were recognised. In the north the Anglesey or North Wales breed, a hardy, slow maturing beef animal, often known as the Welsh Runt and much used in the Midlands for fattening on grass. In the south the Pembroke or Castlemartin breed developed as a milk producer.

The first Welsh Black Cattle Herd Book was published in 1874. The North Wales breeders decided in 1893 to issue a separate herd book, the North Wales Herd Book. In 1904 they amalgamated and in 1905 the Welsh Black Cattle Society published the first combined Herd Book. Since that date there has been only one recognised breed.

Welsh cattle reared as they are under severe climatic conditions are hardy and thrifty and able to produce milk where other breeds would fail. As beef beasts they are somewhat slow to mature. They are commonly crossed with the Hereford bull to produce earlier maturing beef stores. Other breeders cross with the Aberdeen Angus bull.

Dairy Shorthorn—In numbers this breed exceeds any other and is widespread throughout the country. In the latter part of the 19th century the Scotch or beef Shorthorn was able to sell for much higher prices and the dual purpose or dairy Shorthorn which traces back to a strain developed by Bates in Yorkshire, was much reduced in numbers.

In 1905 the Dairy Shorthorn Association was formed and since that date the numbers of Dairy Shorthorn cattle have steadily increased.

In 1935 the Dairy Shorthorn Association merged with the Shorthorn Society. Milk yields are typical of the dual purpose breeds. Beef quality is good and the steers can, if properly fed, make good beef at about two years old. All British Shorthorns, both "Beef" and "Dairy," are registered in Coates Herd Book which is an open register.

Blue Albion—A local breed developed in the Peak district of Derbyshire. The colour is blue or blue roan with some white, but the breed does not breed true for colour. The cattle are horned. A hardy breed of cattle they appear to have been derived from the Welsh and the Shorthorn with some Friesian blood in certain areas. Many are good milkers and feed well for beef. The Breeders Society was formed in 1919.

British White—Formally known as Park Cattle. Both horned and hornless cattle exist in this breed, but only hornless are accepted for registration. White in colour, they have red points, the nose, muzzle, eyelids, teats of the cows, rudimentary teats of the bulls, and the feet. A dual purpose breed. The average yields are reasonably good with a butter fat percentage of about 4.

The breed society was established in 1918.

Longhorn—This breed originated in Lancashire and the Craven district of Yorkshire. Bakewell worked with them and brought about improvement of early maturing and fleshing qualities. After his death the breed became much reduced in numbers but in 1899 a Breed Society was formed. To-day there are still a few herds alive in different parts of the country. Longhorns are dark red in colour with a slight bluish tint. Along the back is a white line and often a white patch on the thigh. The horns are long and down curving.

TABLE 63

RELATIVE NUMERICAL IMPORTANCE OF BREEDS OF CATTLE

Breed	Number of Bulls licensed in			
	England & Wales		Scotland	
	Year ending March, 1947	Year ending March, 1950	1947	1949
Ayrshire	2,365	3,159	4,407	5,309
Friesian	7,110	8,944	306	467
Guernsey	1,379	1,639	3	11
Jersey	661	994	18	29
Kerry	13	9	—	—
Aberdeen Angus ...	478	408	1,147	1,216
Hereford	1,524	1,722	3	12
Galloway	76	93	171	237
Highland	6	4	66	88
Belted Galloway ...	6	3	—	—
Sussex	157	120	—	—
Devon	656	495	—	—
Red Poll	542	473	11	16
Lincoln Red Shorthorn	1,045	927	1	—
South Devon	531	435	—	—
Dexter	23	29	—	—
Welsh Black	412	292	—	—
Shorthorn	13,290	8,836	806	839
Blue Albion	11	6	—	—
Gloucester	4	2	—	—
British White	7	6	—	—
Shetland	—	1	8	12

TABLE 64
AVERAGE MATURE WEIGHTS OF CATTLE*

Breed	Average Mature Weight lb.
Ayrshire	1,000
Friesian	1,250
Guernsey	950
Jersey	800
Kerry	850
Shorthorn	1,250
Red Poll	1,100
Lincoln Red Shorthorn	1,300
South Devon	1,450
Dexter	650
Welsh Black	1,100

* *Bulletin* 48, *Ministry of Agriculture*

TABLE 65
ARTIFICIAL INSEMINATION
Breed Inseminations (Jan.-Dec., 1949)

Breed	Total
Friesian	150,219
Shorthorn	84,504
Ayrshire	46,455
Hereford	38,930
Aberdeen Angus	5,066
Guernsey	29,914
Jersey	11,441
North Devon	7,528
Red Poll	2,980
South Devon	2,913
Welsh Black	1,754
Lincoln Red	396
Total	382,000

TABLE 66

NUMBER OF HERDS OF EACH BREED MILK RECORDED BY NATIONAL MILK RECORDS

Breed	Number of Herds	
	1948/9	1949/50
Ayrshire	2,111	3,225
British White	5	8
Devon	21	24
Dexter	16	22
Friesian	3,922	5,912
Guernsey	1,168	1,708
Jersey	899	1,361
Kerry	15	11
Lincoln Red	71	67
Red Poll	388	491
Shorthorn	5,237	4,968
South Devon	270	372
Welsh Black	99	114

TABLE 67

AVERAGE YIELD OF MILK AND BUTTER FAT FOR EACH BREED NATIONAL MILK RECORDS

Breed	Average Lactation Yield (lb.)				Average percentage Butter Fat		Average yield (lb.) of Butter Fat	
	Cows		1st Calf Heifers		Cows		Cows	
	1948/9	1949/0	1947/8	1948/9	1947/8	1948/9	1947/8	1948/9
Ayrshire ...	8,088	8,177	6,910	7,144	3·81	3·80	308	311
British White	6,714	7,223	4,780	6,781	3·79	3·94	254	285
Devon ...	5,953	5,896	4,606	4,598	4·18	3·99	249	235
Dexter ...	4,986	4,832	4,431	3,714	4·15	4·24	207	205
Friesian ...	9,141	9,296	7,688	7,918	3·45	3·45	315	321
Guernsey ...	7,473	7,382	6,449	6,541	4·56	4·53	341	334
Jersey ...	7,051	7,085	5,851	5,926	5·05	5·02	356	356
Kerry ...	7,203	6,891	5,314	5,179	3·88	3·92	279	270
Lincoln Red Shorthorn	7,487	7,342	5,612	5,884	3·58	3·68	268	270
Red Poll	7,476	7,443	6,185	6,267	3·60	3·59	269	267
Shorthorn ...	7,365	7,447	5,959	6,180	3·58	3·57	264	266
South Devon	6,738	6,808	5,362	5,426	4·26	4·23	287	288
Welsh Black	5,787	5,790	4,661	4,850	4·12	4·10	238	237

TABLE 68
DAIRY BREEDS
Results from 1949 *Dairy Show Milking Trials*

Breed	Cattle over 5 years old			
	Average Live Weight lb.	Average Yield of Milk lb.	Yield of Milk per 1,000 lb. Live Weight	Average Fat
	lb.	lb.	lb.	per cent.
Ayrshire ...	1,198	73·5	61·3	3·62
British Friesian	1,400	82·9	59·2	3·35
Guernsey ...	1,044	53·1	50·9	5·11
Jersey ...	931	49·8	53·5	5·11
Kerry	961	42·1	42·7	4·19

TABLE 69
DUAL PURPOSE BREEDS
Results from 1949 *Dairy Show Milking Trials*

Breed	Cattle over 5 years old			
	Average Live Weight	Average Yield Milk	Yield of Milk per 1,000 lb. Live Weight	Average Fat
	lb.	lb.	lb.	per cent.
Dairy Shorthorn ...	1,264	68·2	53·9	3·33
Lincoln Red Shorthorn ...	1,388	63·7	45·9	3·02
South Devon	1,354	50·4	37·2	3·63
Red Poll ...	1,299	61·7	47·5	3·21
Welsh Black ...	1,270	48·3	38·0	3·56

Table 70

Record Yields of Milk

1951—Cow milked three times per day
British Friesian. Yield 102·9 lb.

1924—Cow milked twice per day
British Friesian. Yield 85·1 lb.

1921—Greatest yield at one milking
Dairy Shorthorn. Yield 47·6 lb.

BEEF ANIMAL BUTCHERS' CUTS

1. Leg.
2. Round.
3. Aitchbone.
4. Rump.
5. Thick Flank.
6. Sirloin.
7. 6-rib Piece.
8. 3-rib Piece.
9. 3-rib and Leg of Mutton Piece (or Chuck)
10. Plate.
11. Brisket.
12. Clod and Sticking Piece.
13. Fore Shin.
14. Thin Flank.

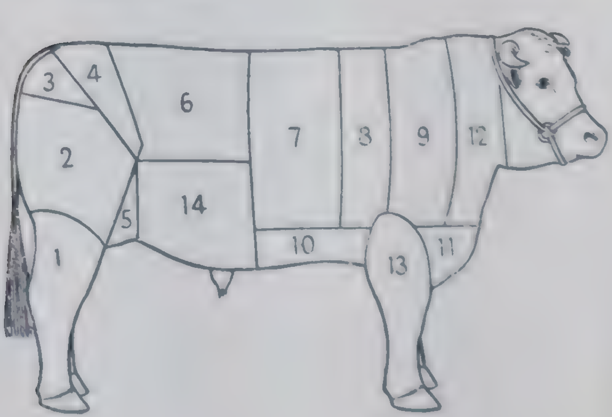


TABLE 71

WEIGHTS OF THE DIFFERENT CUTS FROM BEASTS OF VARIOUS AGES.

	Baby Beef	2-year-old	3-year-old
	lb.	lb.	lb.
Leg (or shin)	11·0	13·0	15·0
Round (or buttock) ...	42·0	58·0	66·0
Aitchbone	8·0	11·0	14·0
Rump	20·0	28·0	33·0
Thick Flank	17·0	23·0	27·0
Sirloin	28·0	38·0	55·0
6-rib piece	22·0	44·0	53·0
3-rib piece	20·0	27·0	40·0
3-rib and leg of mutton piece	40·0	50·0	66·0
Plate	10·0	16·0	33·0
Brisket	15·0	18·0	31·0
Clod and sticking piece ...	22·0	30·0	40·0
Fore shin	8·0	10·0	12·0
	263·0	366·0	485·0
Estimate of live weight ...	950–1,000	1,200–1,250	1,600–1,650

EDIBLE OFFALS—BEEF BEAST

Do not form part of carcase but are sold separately.

1. Tongue.
2. Head.
3. Throat Bread (Thyroid gland).
4. Heart Bread (Thymus gland).
5. Gut Bread (Pancreas).
6. Kidney.
7. Tubes (walls of first and second stomachs).
8. Liver.
9. Tail.

TABLE 72
BEEF CATTLE

PERCENTAGE COMPOSITION OF DRESSED CARCASES

	Protein Per cent.	Fat Per cent.	H_2O Per cent.	Bone Waste Loss Per cent.	Marbling Fat Per cent.
BABY BEEF—					
Store	12·6	12·4	47·4	27·6	3·2
Half-fat	12·5	12·2	48·0	27·3	4·8
Fat	12·3	20·0	44·5	23·2	8·0
ABOUT 2 YEARS OLD—					
Store	12·5	14·3	49·7	23·5	5·4
Store fattened 3 months	11·6	21·0	45·7	21·7	6·1
Fat 5 months ...	11·2	29·7	39·8	19·3	9·1
Fat 6 months ...	12·6	29·2	35·9	22·3	9·4
ABOUT 3 YEARS OLD—					
Store	11·8	20·0	49·0	19·2	4·6
Store fattened 1 month	12·4	20·7	46·6	20·3	5·2
Store fattened 3 months	11·0	29·9	45·0	14·1	7·9
Fat 4 months ...	11·4	36·1	35·2	17·3	9·4
Fat 6 months ...	10·7	31·4	43·1	14·8	9·3

TABLE 73
BEEF CATTLE

PERCENTAGE OF BODY FAT AND CONDITION

Percentage Body Fat	Condition
Less than 5	Very Lean
5–10	Lean
10–15	Store
15–20	Store to half fat
20–25	Half fat
25–30	Moderately fat
30–35	Fat
35–40	Prime fat

TABLE 74
GRADES AND KILLING-OUT PERCENTAGE
FAT CATTLE, 1951

Home Bred Steers and Heifers

Grade	Killing-out Percentage
Super Special	59 and over
Special	58
A+	57
A	56
A−	55
B+	54
B	53
B−	52
C+	51
C	50

Measuring of Cattle for Weight—Each cubic foot of living carcase is equal to 3 stones Imperial of butchers carcase. Therefore 576 cubic inches = 1 stone.

The solid contents of the body (length × diameter^2 × 0·7854) in cubic inches if divided by 576 gives the dead weight in Imperial stones.

Rule 1. Girth^2 × 5 lengths ÷ 21 = weight in Imperial stones. Measure in feet.
Rule 2. Girth^2 × length ÷ 0 7344. Measure in inches.
Rule 3. Girth^2 × length × 0·07958 ÷ 576. Measure in inches.
Rule 4. Girth^2 × length × 0·00013816. Measure in inches.
Rule 5. Girth × length × 23 ÷ 14. Measure in feet.
Rule 6. Girth^2 × length × a given decimal.

In the calculation strike off to the left as many points as are n the decimal. Result is Imperial stones. Measure in feet.

Condition of Beast.	Decimal to use.
Moderately fat	0·23
Fat	0·24–·25
Prime fat	0·26
Very fat	0·27

The length of an animal is taken straight along the back from the square of the shoulder to the square of the buttock. The girth immediately behind the shoulder.

The hide alone in the case of 2-year-old steers shown at Smithfield averaged one year about 6·25 per cent. of the live weight and in the case of the 3-year-olds 6·6 per cent.

Weights of hide ranged from 70 to 112 lb. and the average was 93 lb.

Eight-fourteenths ($^4/_7$) of live weight of butchers' beasts is offal, that is, every Imperial stone of 14 lb. of live weight will yield a Smithfield stone of 8 lb. of dead weight. On this basis the following table is calculated :—

TABLE 75—LIVE AND DEAD WEIGHT OF FAT CATTLE

Live Weight			Dead Weight			Live Weight			Dead Weight		
cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
7	0	0	4	0	0	11	0	0	6	1	4
7	0	14	4	0	8	11	0	14	6	1	12
7	1	0	4	0	16	11	1	0	6	1	20
7	1	14	4	0	24	11	1	14	6	2	0
7	2	0	4	1	4	11	2	0	6	2	8
7	2	14	4	1	12	11	2	14	6	2	16
7	3	0	4	1	20	11	3	0	6	2	24
7	3	14	4	2	0	11	3	14	6	3	4
8	0	0	4	2	8	12	0	0	6	3	12
8	0	14	4	2	16	12	0	14	6	3	20
8	1	0	4	2	24	12	1	0	7	0	0
8	1	14	4	3	4	12	1	14	7	0	8
8	2	0	4	3	12	12	2	0	7	0	16
8	2	14	4	3	20	12	2	14	7	0	24
8	3	0	5	0	0	12	3	0	7	1	4
8	3	14	5	0	8	12	3	14	7	1	12
9	0	0	5	0	16	13	0	0	7	1	20
9	0	14	5	0	24	13	0	14	7	2	0
9	1	0	5	1	4	13	1	0	7	2	8
9	1	14	5	1	12	13	1	14	7	2	16
9	2	0	5	1	20	13	2	0	7	2	24
9	2	14	5	2	0	13	2	14	7	3	4
9	3	0	5	2	8	13	3	0	7	3	12
9	3	14	5	2	16	13	3	14	7	3	20
10	0	0	5	2	24	14	0	0	8	0	0
10	0	14	5	3	4	14	0	14	8	0	8
10	1	0	5	3	12	14	1	0	8	0	16
10	1	14	5	3	20	14	1	14	8	0	24
10	2	0	6	0	0	14	2	0	8	1	4
10	2	14	6	0	8	14	2	14	8	1	12
10	3	0	6	0	16	14	3	0	8	1	20
10	3	14	6	0	24	14	3	14	8	2	0

LIVE WEIGHTS OF CATTLE AT THE SMITHFIELD CLUB SHOW
(Average of four years)

SMITHFIELD SHOW 1949

TABLE 76—WEIGHTS OF PRIZE WINNERS WITH AGE IN MONTHS SHOWN IN BRACKETS

Breed	STEERS				HEIFERS		
	Under 1 year old cwt.qr. lb.	Between 1–2 years old cwt.qr. lb.	Between 2–3 years old cwt.qr. lb.	Over 3 years old cwt.qr. lb.	Between 1–2 years old cwt.qr. lb.	Between 2–3 years old cwt.qr. lb.	Over 3 years old cwt.qr. lb.
Devon ..	7 3 24 (11¾)	11 1 7 (23)	12 1 8 (27)	—	11 2 24 (22)	13 1 24 (29)	—
Hereford ..	6 3 26 (10¾)	11 3 14 (22)	12 0 18 (27)	—	8 0 2 (22)	13 0 10 (33)	—
Shorthorn ...	7 2 4 (10½)	7 3 11 (15)	12 2 0 (28)	—	8 2 27 (17)	—	—
Aberdeen Angus ...	6 3 7 (9½)	11 2 12 (22)	12 0 7 (32)	—	10 1 6 (23)	11 3 25 (34)	—
Sussex ...	5 1 19 (9)	11 2 20 (20)	14 0 3 (27)	—	11 1 20 (21)	—	—
Galloway ..	—	9 2 1 (19)	—	—	—	11 0 8 (35)	—
Highland ...	—	—	—	14 2 10 (44)	7 2 13 (17)	—	—
Red Poll ...	7 3 26 (11)	9 2 7 (16)	12 3 8 (35)	—	—	15 3 20 (33)	—
Welsh Black	—	—	12 0 20 (33)	—	—	—	—
Lincoln Red Shorthorn	—	—	15 3 26 (32)	—	11 0 24 (20)	—	—
South Devon	—	—	16 3 22 (34)	—	—	13 1 11 (30)	—

DENTAL FORMULA FOR A FULL MOUTH

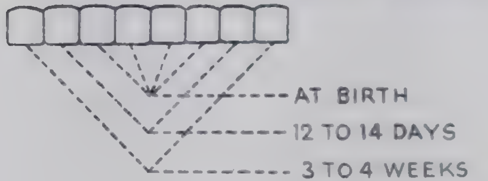
$$\begin{array}{cccccc} \text{P.M.} & \text{T.M.} & \text{INC.} & \text{T.M.} & \text{P.M.} & \\ {}^{3}/_{3} & {}^{3}/_{3} & {}^{0}/_{4} \mid {}^{0}/_{4} & {}^{3}/_{3} & {}^{3}/_{3} & = 32 \end{array}$$

The corner incisors are sometimes looked upon as canine teeth, but are shed like the others.

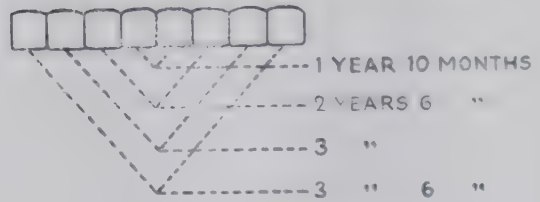
Fig. 11.

TEETH AS INDICATIVE OF AGE

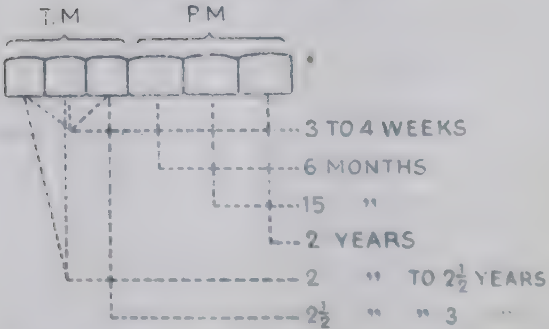
Appearance of Temporary Incisors


AT BIRTH
12 TO 14 DAYS
3 TO 4 WEEKS

Appearance of Permanent Incisors


1 YEAR 10 MONTHS
2 YEARS 6 "
3 "
3 " 6 "

Appearance of Molars


T.M
P M
3 TO 4 WEEKS
6 MONTHS
15 "
2 YEARS
2 " TO 2½ YEARS
2½ " " 3 "

The ox has no incisors in the upper jaw.

Regulations of the Smithfield Club regarding Dentition—Cattle having their central permanent incisors cut will be considered as exceeding one year and six months.

Cattle having their central permanent incisors fully up will be considered as exceeding one year and nine months.

Cattle having their second pair of permanent incisors fully up will be considered as exceeding two years and three months.

Cattle having their third pair of permanent incisors cut will be considered as exceeding two years and eight months.

Cattle having their fourth pair of permanent incisors fully up and their anterior molar showing signs of wear will be considered as exceeding three years.

Names of Cattle

MALE

At birth : Bull calf ; bullock calf if castrated.
First year : Year-old bull ; stott (castrated). Yearling.
Second year : Two-year-old bull ; stott, steer, ox, or bullock.
Third year : Three-year-old bull ; stott, steer, ox, or bullock.

FEMALE

At birth : Quey calf, heifer calf, or cow calf.
First year : Year-old heifer or quey. Yearling heifer.
Second year : Two-year-old heifer or quey.
Third year : Three-year-old heifer or quey ; becomes a cow on bearing a calf.

" Stott " is sometimes applied to a bull of any age, and sometimes to an ox or steer after the fourth year. " Segg " is applied to a bull castrated after service.

" Stirk " is limited to males and females under two years in Scotland, while it is usually applied to females only in England, the males being " steers."

" Heifer " is almost universally applied in England to a young cow in calf, but in some places, especially in Scotland, it is limited to speyed animals.

A cow after being served with bull should be an " in-calver." If she proves barren, is " eild " or " farrow " ; when she stops yielding milk, is " yeld " or " dry." When a bull and quey calf are dropped at one birth, the latter is generally a " freemartin "—that is, barren.

Rearing of Cattle—All young cattle whether intended for breeding or fattening must be well reared. This is particularly important during the first six to eight months of life. Economy of feeding at this stage if it results in a reduction of growth rate is bad practice. All calves should receive colostrum for the first three or four days. This food is highly digestible, laxative and increases the animal's resistance to certain diseases.

Calves may be then reared in one of three main methods :—

1. Natural, each cow suckles her own calf.

2. Semi-natural, that is a cow suckles two or more calves during her lactation.

3. Artificial or pail feeding.

The natural method produces the best calves but is the most costly. In dairy herds where milk sales are important it is not possible, nor where the cow is a heavy yielder is it feasible. It is normally confined to beef cattle. The semi-natural method is also found in beef producing cattle particularly where baby-beef cattle are the aim, on store rearing farms and at times in dairy herds. In this system several calves, as many as 12, may be reared per cow. The number depends largely on the milk yield of the individual cow. The cow may, for example, suckle four for three to four months, then another four and finally a pair of calves.

The management, care and supervision must be very good when this method of rearing is used.

Example of Semi-natural Method using a good milking cow :

1st	calf	suckles	1–13th	week.
2nd	,,	,,	1–14th	,,
3rd	,,	,,	3–17th	,,
4th	,,	,,	14–27th	,,
5th	,,	,,	15–28th	,,
6th	,,	,,	18–31st	,,
7th	,,	,,	28–41st	,,
8th	,,	,,	32–45th	,,

Pail feeding whilst rarely producing such good results as the more natural methods is used with the object of economising on milk consumption per calf. Whole milk substitutes should not be introduced until the calf is at least three or four weeks old and the substitution should be gradual. Substitutes may be separated milk, whey, gruels of various sorts or dry meals. Rates of growth using substitutes are not as good as when the calf is on a whole milk diet as shown below.

	Rate of Live Weight gain per day in lb.
Whole Milk	2
Separated Milk ...	1½
Whey	1–1¼
Dried Food	1¼

The use of dry food as a substitute for whole milk is entirely satisfactory, the substitution commencing during the fourth week and weaning taking place during the twelfth week.

A method of pail feeding using whole milk and dry food is given below and is suitable for Ayrshire or Shorthorn breeds. For larger breeds increase amounts.

TABLE 77

Week	Milk per day	Meal per day	Hay per day
	qts.	lb.	lb.
1	3	—	
2	4	—	
3	4	¼	Start to feed in second or third week and increase the amount steadily to about 3–4 lb. at 12 weeks old.
4	4	¼–½	
5	4	½	
6	3	2/3	
7	3	¾	
8	2	1	
9	2	1¼	
10	1	1½	
11	1	1¾	
12	—	2	

Where gruels are used great care must be taken to prepare them properly and to clean the feeding buckets thoroughly.

Mixtures of dry foods as a milk substitute :—

	Per cent.
1. Crushed oats	40
Flaked maize	20
Broken linseed cake ...	30
White fish meal	10
2. Crushed oats	30
Rolled barley	20
Bran	10
Linseed Cake	10
Dried separated milk ...	20

COMPOSITION OF NATIONAL CALF STARTER FOR USE AS GRUEL

	Parts by weight
Dried whey powder	30
Dried skim milk	15
Linseed cake meal	30
Feeding wheat flour ...	10
Oats	10
Dried grass meal	2½
Carbonate of lime	1¾
Common salt...	¼

Very good hay should be offered to animals at two to three weeks old. Water should be readily available at all times.

Food consumption of typical Shorthorn heifer calf at three months :—

	lb. per day
Meal	2–2½
Hay	3–4

At six months :—

Meal	3½–4
Hay	6–7

General Points of Management in Calf Rearing—

1. Navel may be disinfected daily with iodine until it is dry.
2. Calves are best kept in single pens until weaned. In groups. steps must be taken to prevent suckling each other.
3. Calf shed should be well lit, well ventilated and free from draughts. Bedding generous.
4. Pail fed calves should be fed three times per day for at least first three weeks.
5. Milk rich in fat must be diluted with water. For Channel Island breeds about 25 per cent. dilution of the milk is necessary.
6. Milk should be fed at blood temperature.
7. All feeding buckets must be sterilised daily.
8. Cod liver oil is a valuable addition to the diet at two teaspoonfuls per calf per day.
9. If digestive trouble occurs withhold milk for a day and give diluted milk for a day or so after that.
10. Green food, for example kale, is a valuable addition to the diet.
11. Dehorning should be carried out between the second and seventh day with caustic potash. If the electric method is used the horns should be about 1 in. long before treatment.
12. Bulls are castrated at two to six weeks old.
13. Vaccinate with S.19 against contagious abortion at four months old.
14. Supplementary teats should be cut off during the first week of life using surgical scissors.

TABLE 78
COMPARATIVE WEIGHTS OF CALVES OF DIFFERENT BREEDS AT BIRTH

	lb.
Jersey	60
Guernsey	70
Ayrshire	75
Shorthorn	85
Friesian	90
South Devon	100

These weights are about 7 per cent. of those of the dams

Rearing after Weaning. For Baby Beef—Calves intended for baby beef must be reared well either suckling a good yielding cow or pail-fed on a generous allowance of milk and weaned late. Foods must be easily digestible and palatable. Growth and fattening must proceed without check if the animal is to be sold fat at 14 to 18 months old.

Suckled calves born in late winter or early spring and run out at grass will usually not need extra food before August. If housed they should receive cut green food. During autumn and winter they must be fed well.

Suitable daily rations :—

		lb.
1.	Turnips	30–35
	Hay	7
	Crushed oats	4
	Linseed cake	1¾
2.	Oat and tare silage ...	15
	Hay	5
	Rice meal	2
	Barley meal	3
	Linseed cake	1½

As winter proceeds increase roots and silage also concentrates up to about 7–10 lb. per day.

Calves for Fattening after Growth into Mature Stores—Rate of feeding is less than that for baby beef. The store is expected to increase in weight after six months of age at an average of 1–1¼ lb. per day.

The following rations indicate scale of feeding used during the winter periods :—

Age 6 months, weight 4 cwt.

	lb.
Roots	15
or Silage	10
Hay	5
Dec. ground nut cake ...	1
Crushed oats	3

Age 6 months, weight 3½-4 cwt.

	lb.
Swedes	15–20
Hay	3
Oats	1½
Flaked Maize	1½
Palm nut kernel cake ...	¼
Fish meal	½

Age 12 months, weight 5½ cwt.

	lb.
Oat straw	7
Swedes	40
Palm nut kernel cake ...	3

Age 15 months, weight 6 cwt.

	lb.
Hay	10
Mangold	30
Oats	4
Dec. ground nut cake ...	½

Age 2 years, weight 8 cwt.

To be fed into a forward condition and to increase in weight by 1½ lb. per day.

	lb.
Hay	7
Oat straw	7
Swedes	30
Maize meal	2
Palm kernel cake	3

Silage is an excellent food for stores and may replace greens, roots, hay and if it is of good enough quality, meals and cakes also.

Replacement values :—

2½–3 lb. medium quality silage = 1 lb. medium hay,
or 5 lb. roots,
or 3½ lb. kale,
or 1¾ lb. oat straw.

Ration for a 15 months old store using silage :—

	lb.
Oat and tare silage	40
Mangold	10
Coconut cake	2

Rearing of Dairy Heifers—Calves are not usually turned out to graze before they are four to six months old. Then they should graze on first-class clean grassland, preferably young leys. They should not mix with older cattle. Calves kept inside benefit by receiving fresh cut green food or cod liver oil in lieu.

Calves out during the summer should be housed from the middle or the end of August.

Specimen rations for heifer calves from six months of age. Based on the Shorthorn :—

Age 6 months

		lb.
A.	Roots	10
	or Silage	5
	Hay	5
	Linseed cake	2
	Oats	2
B.	Oat and tare silage	10
	Hay	6
	Kale	10
	Oats	2

Age 12 months

	lb.
Roots	20–30
or Silage	10–15
Hay	10
Oat straw	6
Crushed oats	2
Beans	1

Age 18 months

	lb.
Silage	15
Hay	5
Oat straw	10
Mangolds	30
Beans	1

Age 24 months

	lb.
Mangolds	40
or Silage	20–25
Hay	15
Oat straw	10

Kale and cabbage may be fed in lieu of roots. Concentrates to be carefully rationed. Good silage may replace part or whole of the meals and cakes.

In summer yearlings and two-year-olds will obtain adequate food from grassland.

Yearlings are most commonly housed in winter either in yards or stalls. Older heifers are similarly housed although in parts of the country they may be out-wintered.

Breeding—Cows are mated for the first time at ages which vary with breed, farm policy and the state of development and growth of the animal. The following table shows typical ages for certain breeds :—

Table 79

	months
Jersey	12–15
Guernsey	16–18
Ayrshire	18–21
Shorthorn	21–24
Lincoln Red Shorthorn ...	21–24
British Friesian	21–24
Welsh Black	21–24
South Devon...	24–27

At the present time certain farmers calve down their dairy cows at younger ages than was once thought desirable. For example, Friesians, Ayrshires and Shorthorns at two years old. To calve animals down successfully at this young age demands good rearing from birth.

TABLE 80

OESTRUM (HEAT) PERIODS

Duration of Oestrum	Return after Parturition	Return if no Conception
A few hours up to one day	21–28 days	Approximately 21 days.

Period of Gestation is—281–285 days.
40–41 weeks.
9½ months.

Signs of Pregnancy and Approaching Parturition—Given in general order of occurrence :—

1. Heat periods cease.
2. Milk yield shows slight fall about 140 to 150 days after conception.
3. At about sixth month calf may be felt through the right flank.
4. Udder increases in size and later may become hard and painful.
5. Ligaments around the tail loosen.
6. Animal walks unsteadily.
7. Animal becomes uneasy and appetite may become poor.
8. Bladder appears and bursts.

The calf should then be born within a short period.

Signs of Normal Health in Cattle—Appetite keen ; anima chews cud contentedly ; dung semi-solid ; urine a clear colour ; passage of dung and urine several times a day ; coat shiny, animal bright and alert ; eyes bright and not sunken ; breathing easy ; lick marks on coat ; animal quiet and content ; milk yield showing only slight day to day variations ; horns norma to touch, that is neither hot nor cold. Temperature : 101·8° t 102·4° F. ; Pulse : 45–50 per minute ; Respiration : 12–16 pe minute.

ARTIFICIAL INSEMINATION

Artificial Insemination (A.I.) consists in collecting the male semen and inserting it at the appropriate time, that is just before the egg is shed, into the female tract. There is some evidence that it was practised in ancient times in Arabia on horses, but the first scientific experiments were made on dogs in Italy by Spallanzani in 1780. Since that time it has been used by veterinarians for the cure of certain forms of sterility mainly in mares and bitches. It was not until about 1920 however that its use in general breeding practice with farm animals became possible through the discovery of keeping the sperm alive outside the body, of diluting it satisfactorily and by the invention of new methods of collection. Since that time its use in breeding practice has extended considerably in U.S.S.R., Denmark, U.S.A. and this country and is rapidly extending to other countries. The first Centre for cattle in this country was established in 1942 and the number of dairy cows inseminated has more than doubled each year since then, over half a million having been inseminated in 1949.

The practical large scale use of A.I. in horses has been confined mainly to U.S.S.R. and Eastern Europe (where it is used to control the spread of dourine, a venereal disease) and to mule breeding areas because the sperm of the horse cannot yet be kept alive for long outside the body, and so collection and insemination have to be done on the spot. For the same reason A.I. has made little or no progress in pig breeding. The large scale use of A.I. in sheep has also been confined chiefly to U.S.S.R., South America and East Africa where the large size of the flocks and the high value of imported rams have warranted its use. The sperm of the ram will keep well outside the body and long distance transport by air mail has been used, for example from this country to Poland and from the Eastern to the Western side of U.S.A. This is also true of bull sperm and successful long distance transport has been made from U.S.A. to Australia and Italy, and from Canada to this country. This long distance transport of bull and ram semen will probably extend greatly in the near future for it is less costly than the transport of live animals.

In this country, and in many others, the most widespread use for A.I. has been with dairy cattle and there are several reasons for this. In the first place the average size of dairy herds is small (about 10 cows in this country) and the keeping of any bull, let alone a good one, would be uneconomic. The alternative of sharing a bull with other herds risks the spread of diseases such as contagious abortion or trichomonas infection causing abortion and sterility, and often leads to promiscuous crossbreeding. Secondly, the average time which a bull is kept in small herds (2 to 2½ years) makes the depreciation costs high (bought at pedigree and sold at butcher's price) and increases the total number of bulls required each year (39,500 were licensed in 1943 before A.I. was introduced) to such an extent that many bulls without pedigrees or milk records behind them had to be used. The reasons for the short life of bulls in one-bull herds are to avoid mating him to his daughters, the difficulties of housing a large bull and of using him on small heifers. As a consequence of all this, until the advent of A.I., there was very little chance of bulls being carefully selected to breed replacement heifers and this is the chief purpose of A.I. for dairy herds.

The traditional method of improving the milk yields of dairy herds in this country has been to milk-record the yields of the cows and cull the bad milkers. This is a sound but slow method, and the cow is culled after the loss from low yield has been sustained. A more economical method is to make better selection of the bulls used so as to prevent bad milkers from being born which is more rapid in effecting improvement. In primitive countries where there is no castration of bulls there is no chance for improvement by selection. Under a system of natural mating in this country one bull is kept for about 30 cows, but with A.I. the ratio is about 1 bull to 1,000 cows. Thus, with a system of A.I. breeding, selection of the bulls may be a thousand times as effective as selection of the cow for increasing milk yields. It is a common saying that the bull is half the herd because in the next generation the calves derive half their " blood " or genes (the elements in the animal which control the production of the characters and which are derived from the parents equally by way of the sperm and egg) from him and the other half from all the cows, perhaps 30 or more, in the herd. Two bulls used in the herd in successive generations will contribute 75 per cent. of the genes in the herd, three bulls 87½ per cent. and four bulls in succession 93¾ per cent. The importance of the proper selection of the bull is therefore obvious. This forms the basis of the " grading-up " schemes, whereby, after the use of a succession of pedigree bulls on a " foundation " cow, the offspring are admitted to the herdbook as fully pedigree. The same principle applies to breeding for high milk yield : in order to obtain a herd which will breed true for high milk production, a succession of bulls breeding true for milk must be used.

In breeding for beef it is possible to select breeding animals by conformation at all ages and in both sexes, but in breeding for milk it is not possible to select females until after the first lactation and in males until after their daughters have had their first lactation, by which time the bull is about six years old.

After this age proper selection of a bull for milk production can be made on the basis of the average yield of all his daughters in milk. Such bulls are called Progeny Tested bulls and if their daughters' average yield is above the breed average they are considered Proven. These Proven bulls form the key to successful breeding for high milk and butter-fat production, for if they are used not only to breed large numbers of heifers by A.I. but also to breed young bulls from cows which have high lifetime production records, the next generation of young bulls contain many more animals which will themselves in turn become Proven bulls.

A.I. can be used not only to improve milk production but also beef production in this country where, owing to lack of sufficient space for breeding pure beef cattle in the numbers required, a high proportion of the cattle for fattening must be bred in dairy herds. In the past these have been obtained from the steers of dual purpose cows kept in dairy herds, but such steers are on the whole inferior to pure beef-bred steers although they are cheaper to produce. By using A.I. it is now possible to inseminate the best two-thirds of the cows in the dual purpose herd from a dual purpose bull to provide replacements for the herd and to inseminate the worst third with semen from a pure beef bull to provide better calves of both sexes to be reared for fattening purposes. It is essential for this purpose however that the two types of calves, dual purpose and crossbred-beef, should not get mixed up and so for this purpose a beef bull should be used which "colour marks" its calves. Where the dual purpose breed is red, white or roan, as in the Shorthorn, a beef breed bull, such as an Angus (black polled) or Hereford (white face) marks his offspring, for the black colour and white face are "dominant" in inheritance, i.e., they dominate the other colours in the first-cross animal.

The technique of artificial insemination in cattle varies slightly in different countries. In Denmark and U.S.S.R. a method of embedding the semen in gelatine and insertion into the cervix is used. In U.S.A. and in this country the usual method is dilution with an egg yolk—phosphate or citrate solution, and insertion into the uterus. Collection of semen from the bull is made by getting him to serve into an artificial vagina (a rubber cylinder surrounded by a water jacket at body temperature) when he jumps a cow (not necessarily on heat) confined in a crate. The semen is then examined under the microscope and if it is a good sample it is diluted (4 to 20 times or more) with a diluter made up of equal parts of fresh egg yolk and phosphate (or citrate) buffer solution. This not only dilutes the semen but prevents it suffering from temperature shock when it is cooled down for storage. The best temperature for storage is 40° F. and it can be kept for up to four days. Insemination of the cow is made when the cow is on heat or for up to about six hours after the end of heat, for the egg is not shed until about 14 hours after the end of heat. To inseminate the cow a 2cc. syringe with a rubber connection is used. Into this is inserted a thick glass tube up which is sucked 1 cc. of diluted semen. A fresh sterilised glass tube is used for each cow so as to avoid spreading infection. One hand is inserted into the rectum and with the other the glass tube is inserted into the vagina and upwards to the cervix which is pulled over its end by the hand in the rectum. When the end of the glass tube is through the cervix and into the uterus the plunger of the syringe is slowly pressed and the semen is injected into the uterus. It is because the semen is injected into the uterus that so many more cows can be inseminated from a single jump of the bull than can be done in natural mating where the semen is inserted into the vagina and only a small proportion of the sperm ever reaches the uterus.

The practice of A.I. in this country is regulated by legislation. While anyone may inseminate his own cows, a licence from the Ministry of Agriculture must be obtained to sell semen. Licences are of two sorts : Article 3 licences are for private owners for a limited number of cows in a limited number of herds ; Article 2 licences are for Societies covering a certain area and doing an unlimited number of cows. Societies may be of two sorts : those financed by the Milk Marketing Board with local Committees of Management ; and those financed by local Farmers' Companies, Creameries, etc. The bulls used by these Societies must be of high genetic worth and free from diseases such as tuberculosis, contagious abortion, trichomonas infection, etc., and they must be housed in special centres isolated from other cattle. Such Centres are in the charge of a Veterinary Officer and serve a radius of about 12 miles ; with increase of this radius transport charges rise rapidly and so where concentrations of cows exist outside this radius Sub-Centres are set up to which semen is sent from the main Centre each day for distribution. Telephone calls to the Centre are usually made before about 10.0 a.m. by farmers having cows on heat, this being the time the inseminators normally set out. Inseminators carry, in addition to equipment and thermos flask containing semen, a book with counterfoils in which the details of the insemination are entered. These act as receipts and evidence of service for pedigree purposes i the owner of the cow so desires. With some exceptions, the usual charge made is 25s. for, if necessary, up to three inseminations, for each cow. About 64 per cent. of the cows hold t service at the first insemination (calculated on those which do not "turn" up to three months after insemination) which is some 4 per cent. higher than those actually calving. This figure is much the same as that obtained from natural matings in diary herds.

BREEDS OF HORSES

The Heavy Breeds : Shire, Clydesdale, Suffolk, Percheron

Development of mechanical power on the farm has latterly proceeded so rapidly and has been so varied in its purpose as to constitute a serious threat to the heavy horse. As a result of increased cultivation and the greater prosperity of the farming industry during the war years and since, the horse has been replaced by the tractor to an extent which is causing the authorities some dismay. For while the extended use of motor power is inevitable in a progressive industry, the importation of every gallon of motor fuel needed might in emergency impose undue strain on the transport protecting service.

On the small or medium farm the heavy horse should still find a place on account of its handiness, adaptability, and reliability in most circumstances. Even on the larger holdings the farmer is liable to be confronted with tasks uneconomical for the tractor yet well within the capacity of a sound horse. To use a 20 h.p. tractor for a one-horse job is wasteful of power and very costly.

Shires—In England and Wales the Shire still holds a numerical superiority over the three other heavy breeds—Clydesdale, Suffolk and Percheron. For centuries it has been the main source of farm field power. Some have traced its origin to the war horse used in the French campaigns of the Tudor kings. Bred mainly in the Midland counties, its type exists throughout the country, and the colour ranges from the blacks and greys which were popular in the early days of organised Shire breeding to dark browns, browns and bays. The blacks and greys, indeed, have a way of cropping up and creating a fashion from time to time, but in between such periods, the dark browns predominate.

In maturity the stallion weighs from 17 cwt. to a ton and stands 17 hands high. Clean, flat bone on massive legs is looked for, and the action must be straight and free. Present tendency is to limit the amount of hair on the legs to give the animal a clean limb free from the threat of grease. In spite of the weight and power the Shire is an easy mover and the characteristic willingness and courage, combined with a general clean bill of health, have brought widespread popularity as a source of adaptable animal power.

Clydesdale—Although originally found and developed chiefly in the Valley of the Clyde the great Scottish horse is capable of meeting varied conditions in many countries outside its own. Special attention has been devoted to the maintenance of a type with legs and feet that wear well and stand the shock imposed by the granite setts of cities as well as the strain of heavy clay land. Greater importance is now attached to the wearing qualities of the limbs than to mere weight.

Clydesdale stallions average about 16.3 hands, the mares 16.1 hands; the popular colour is dark brown, sometimes even darker and approaching black, with a little white on the face and with one or more white feet. Strength of constitution and freedom from vice are conspicuous virtues and their fast walking pace gives Clydesdales an air of activity and fitness which makes them popular on the small mixed farm.

From Scotland the breed has spread throughout the northern counties of England and is probably the best known of all British heavy breeds in overseas countries, especially in the countries of the British Commonwealth. Exports were resumed on a fair scale immediately after the 1939-45 war.

Suffolk—The great horse of the Eastern counties is famous for its clean legs, quick movement and power. The nickname—the "Punch"—may be an indication of the girth behind the shoulder or may have had something to do with the more thickset type prevalent in the past. Yet the Suffolk has probably been subjected to varying fashionable points less than other breeds, having always been bred for its strength of limb, excellence of feet, and shapeliness of hoof.

Colour, too, has altered but little. From earliest times clean-legged horses of the Eastern counties have been brown, some say ever since the Norman invaders brought horses over with them. To-day a bright shade of chestnut is in favour, with the mane and tail sometimes of a light or blonde shade. For the thick withers, the deep barrels, and the well-rounded quarters the legs look rather light but their freedom from hair gave the Suffolk an advantage when, after World War One, the demand was for hairless legs, especially in horses intended to work on heavy soils. The Suffolk has a reputation for soundness.

Percheron—Few people in Great Britain were aware, before the 1914-18 war, of the existence of the Percheron breed of horses. It was one of the heavy breeds of France, and proved so efficient in that conflict that British horse breeders serving on the Continent organised the importation of a substantial contingent to form the foundation of a definite type to serve on the farms and in the towns of this country.

British-bred animals have increased greatly in numbers and are popular for their handiness, their good health, and their trouble-free limbs.

The general colour is grey, with an occasional black. Stallions weigh from 16 cwt. to a ton, with a height of between 16 and 17 hands; the mares, averaging about 16.2 hands, weigh from 14 to 16 cwt. Even at big weights the Percheron is a quick mover and can shift heavy loads smartly and willingly. The breed requires the minimum of attention and can carry on with moderate rations.

No matter what breed of mare is put to the pure-bred stallion, the clean limbs are transmitted to the progeny. Resistance to disease, longevity and regular breeding have strengthened their hold on the work of British farms and among commercial users of horses.

The Light Breeds: Hackneys, Thoroughbred, Hunters

Hackneys—Hackneys are less seen to-day, but at one time they were very popular and certainly the showiest of our British breeds, with spectacular leg action in harness, great pace and high courage. In tandem or in pairs they commanded attention. The International Horse Show in the early days at Olympia, largely centred around the gaiety of the driven Hackney. Yet the ride-and-drive type of Hackney is still being bred by a few enthusiasts who are determined not to allow a peculiarly British breed whose speed and endurance demonstrate the frequent infusions of Thoroughbred blood to die out.

At one time the Hackney, next to the Thoroughbred, was the horse most in demand for export. Prize-winners of elegance possessing high leg action went especially to the United States and to South America. General height is 15 hands; sound feet and clean legs with a touch of white are essential.

Thoroughbred—Britain's best known horse, used the world over not only for racing but for crossing to add speed and perhaps elegance to other horses and ponies, is the Thoroughbred. The breed was founded by Charles II who introduced the best Barb, Arab, or Turk mares procurable. From these three, great lines were derived leading to the stallions Herod, Eclipse and Matchem, from which are descended the greatest of modern racehorses. Speed is the dominant requisite and must not only be possessed by a Thoroughbred but also indicated by the general appearance.

Hunters—A horse for hacking as well as for following hounds naturally requires speed and courage. The Hunter has been bred with these qualities most in view although with a considerable variation in conformation in consequence. The Thoroughbred stallion is very largely used and although a fair proportion of pure-bred animals exist most Hunters are the progeny of mares of proved prowess in the hunting field sired by a Thoroughbred stallion. Light cart mares and pony mares are sometimes successfully mated with the Thoroughbred. But substance, quality, speed and endurance—all essential factors—are not easy to combine and often the progeny of breeding from pony mares lack the size so much sought after. Good hunting ancestry on the dam's side is therefore desirable.

Ponies : Exmoor, Fell, Highland, New Forest, Polo, Shetland, Welsh Mountain

Ponies vary in height from as little as 8½ hands to about 14 hands and the native breeds are Dales, Dartmoor, Exmoor, Fell, Highland, New Forest, Shetland, Welsh.

Exmoor.—These ponies and those of Dartmoor have several points of resemblance. Both are used for the breeding of Hunters and Polo ponies.

Fell.—This is one of the largest of British ponies, standing up to 14 hands. It is thickset and powerful, and usually black or dark brown. In its native Northern counties and elsewhere it is often known as the Galloway, being noted for speed, great activity, and sound constitution.

Highland.—This breed is very varied in type but can often be recognised by the stripe along the back. Standing up to 13 to 14 hands, these ponies are remarkable for great strength in relation to size. They are sure-footed, hardy, and able to live on rough pasture throughout the year.

New Forest.—Running more or less wild in the New Fores of Hampshire, this breed of grey ponies possesses a measure o Thoroughbred blood to which their spirit and speed is due They have strong constitution, stand from 12.2 to 13 hands and the mares are often used for breeding up to the standar laid down for polo and riding ponies.

Polo.—Native British ponies have formed the basis for th development of this distinct breed, aided by the introductio of Thoroughbred and Eastern blood. Breeders have a preference for mares with a good polo-playing record, especially thos likely to produce progeny with substance and weight-carryin ability as well as quality and speed.

Shetland.—At one time this breed was in great demand fo pit work in the North of England but the modern Shetlan the smallest (7½ hands to 10 hands) of British breeds, is wante mainly as a first riding pony for children and for light harness

Welsh Mountain.—This is perhaps the oldest breed of nativ pony, running semi-wild on the mountains of Wales. Note as a sure-footed, handsome animal, natural and true in th gallop and an excellent jumper, it has been used as the founda tion for many other successful types. It averages 12 hands in height and in colour varies greatly, with a preference for grey.

A type of small horse in favour to-day is the **Cob.** These are short legged and stand about 14 hands. They carry more bone than most ponies and are mostly crosses of heavy breeds of horses with a pony breed.

BREEDING—MANAGEMENT OF MARE AND FOAL

The type of horse required nowadays is lighter in build, active and carries less hair and bone than was required formerly. Mares and stallions must be pure bred, of good pedigree and high individual merit. Under the Horse Breeding Act stallions are disqualified if suffering from cataract, roaring and whistling, ring bone, side bone, bone spavin, navicular disease, stringhalt, shivering and defective genital organs.

Fillies should not be mated until they are two years old. A colt may be used at two years to serve a small number of mares. When three years old the colt may serve as many as 60 mares per year and the mature stallion eighty.

The foaling season may be at any time in the period January to September. The most convenient period for agricultural horses is April to June. Thoroughbreds are frequently foaled from January to March.

The period of gestation averages a few days over 11 months with a variation either way, of 10 to 14 days.

Oestrous occurs four to seven days after foaling and lasts from five to seven days. Successive heat periods occur at intervals averaging 21 days.

A successful service is more probable if it takes place two to four days before the end of oestrous. The mare should be in a thriving condition and fit for work.

Exercise for in-foal mare—Under a good horseman a mare may be given ordinary farm work during the first six months of pregnancy. After this she should not be worked in shafts nor given very heavy tasks. She may be worked in chains to within a week or so of foaling. Confinement and lack of exercise during the final few weeks of pregnancy is bad management. Idleness, provided she is out at grass, will do no harm. As foaling time approaches care must be taken that the mare's diet is laxative. Nor must she be overheated. Her needs are met by feeding a ration for slightly harder work than she is actually performing.

Foaling—The approach of foaling is indicated by a loosening of the muscles around the tail head, a swelling of the udder and by the appearance of waxy drops on the end of the teats one or two days prior to parturition. The mare may be put in a box or paddock to foal. The box should be large, clean, airy and light. The duration of labour is usually short, about one hour, and difficulties of presentation rare. It is important to see, that the mare cleanses properly. After the navel cord is cut, mare and foal are best left alone.

Rearing of the Foal—Management of Mare—It is important that the mare receives laxative and good food after foaling, for example bran mashes and clover hay. After two or three days, in suitable weather, mare and foal may be put to grass during the day. Gradually increase the period at grass until they are lying out at night. Normally this will be two to three weeks after foaling. If foaling has been early in the year greater care is required. In such a case it is important to see that the mare is given adequate daily exercise. Once mare and foal are lying out hand feeding should not be necessary.

The mare should not be worked for a month after foaling. It is probably advisable not to work her until after weaning. If she is used for work prior to weaning the tasks must be easy and of short duration and not likely to cause her to sweat. She should not be separated from the foal for more than two or three hours. If worked prior to weaning feed her for the work done plus 3-4 lb. of mixed corn per day.

During the first summer, foals should be handled, accustomed to the halter and led about. These early lessons continued regularly are invaluable.

Weaning is usually effected when the foal is four to six months of age and should not be gradual. Separation should be sudden and final. The foal should be closely confined for two to three days and then put back to pasture. The mare should be put to work to dry her off.

If the pasture is good the weaned foal will not require any other food, but if weaning is late in the year, or the foal backward, or grass poor, a good supplement is crushed oats and separated milk.

During the foal's first winter it is common except in mild places to house at night and turn out by day. It is necessary to feed well, for example oats 4 lb., bran 2 lb., chaffed hay 4 lb., in two feeds daily. When there is frost or snow spread some dry hay on the pasture.

The summer pasture should not be too rich and mixed stocking is preferable to putting the animal to graze by itself.

During the second winter only a little hay may be necessary in addition to grazing although for a short period usually after the New Year up to 6 lb. grain per day may have to be given depending on condition of climate and animal.

Colts should be castrated when about one year old when weather is mild, but not too warm. It is a dangerous operation and should be performed by a veterinary surgeon.

Breaking In—Horses are usually broken in when 2½ years old. The process should have started when the animal was a foal. The usual procedure is to accustom the animal to harness, then lead it about. The next stage is to drive it on long reins and teach it to answer to the bit. This requires great care if damage to the mouth is to be avoided. Finally the animal should be put to work ploughing beside a steady horse. The young horse should be put in the furrow to teach it to walk straight. Work in shafts should not be attempted for some months. The young horse should not be worked more than an hour or two per day at first. By the time it is three years old it should be fit for regular work.

Feeding and Management—A horse has a small stomach and should be fed little and often. A horse in hard work should be fed regularly at least three times per day and allowed one hour per meal. Large meals after heavy work are undesirable. Water should be given four times each day, usually before meals and certainly not at once after a meal. Loosen girths prior to watering. If a horse is very hot and tired offer limited quantities of water at short intervals until thirst is quenched. If horses are stabled in summer, give a last watering about 9-10 p.m.

Oats and hay are the basic foods for horses. Oats should be good and not new, hay clean, not dusty, mouldy or otherwise spoilt. Maize, barley, beans, bran are also frequently used. Oat straw may replace part of the hay ration.

A horse in regular work should be fed according to size, condition and nature of work. A typical ration for a 1,500 lb. horse doing heavy work being good hay 14 lb., oats 20 lb., some of the hay being fed as chaff with the oats. 3-4 lb. beans may replace part of the oats. On regular but not very heavy work a ration such as the following will suffice. Crushed oats 12 lb., bran 2 lb., hay 14 lb., or oats 16 lb., hay 16 lb., swedes 10 lb.

During idle periods the grain feed must be reduced. A common practice is to feed a bran mash instead of grain on Saturday nights, both as a laxative and as a precaution in view of the Sunday rest. The reduction in grain feed is especially necessary after some days hard and continuous work.

During the summer and when the horses are not worked hard a feed of about 6 lb. oats or mixed concentrates for every half days work done is adequate.

Clipping and Grooming, Shoeing—The more work a horse performs the more it sweats and greater the need for grooming. Work horses should be groomed at least once per day. If horses arrive at stable sweating the sweat scraper and hay wisp should be used to take off sweat. Horses legs should not be washed regularly, rather allow mud to dry on and then brush it off.

At the start of winter before coat is fully grown clip trace high. Head, neck, back, quarters are not clipped. The hair on coat is left on down the flanks and body to a point level with point of shoulders and straight back. Legs are clipped down to halfway between elbows and knees on front legs and stifle and hock on rear legs.

Shoeing is generally necessary at intervals of 6-8 weeks.

Bedding—Bedding should not be left down all day, floors should be swept at least once per day and hosed at least once per week. Old bedding fit to use again should be placed on top of and across new straw. Placing straw in this manner makes a more elastic bed.

Ages—A good sound horse should continue working well into its teens. Individuals have attained great ages, one horse having lived for 42 years. The age is indicated by the teeth. At birth a foal has two temporary incisors, these increasing to six about nine months of age. At about 2½ years the first two permanent incisors usually appear, the second pair appear at 3½ and the third pair at 4½. The two canines also appear at 4½. Thus by five years of age a horse has all its permanent teeth. Thereafter age may be estimated by length and shape of teeth. This requires considerable practice.

Judging—Many points must be studied in judging a horse. Certain points are more important than others. In all breeds and types certain things are regarded as desirable. The head should be strong and wide between the eyes, which should be prominent and of good size. Neck to be long, well muscled with shoulders moderately sloped back. Back and loin to be short, fairly straight and well muscled. Hind quarters well developed, long and wide. Ribs well sprung, chest wide and deep. Forearms and thighs must be muscular with pasterns fairly long and slightly sloped. Fetlock or pastern joint well angled and not too long. Hind legs should not be turned out too much at the hocks which should be broad and flat. Feet to be deep, solid, with concave soles and wide open heel. The movement of the horse whether walking or trotting should be free and easy.

Names of Horse

Horse

During 1st year—Colt foal.

During 2nd year—Yearling colt.
During 3rd and 4th year—Two- and three-year-old.
At 3 years of age Entires or Stallions : Geldings if castrated.

Mare

During 1st year—Filly foal.
During 2nd year—Yearling filly.
During 3rd and 4th year—Two- and three-year-old.
At 3 years of age Mares.

BREEDS OF PIGS

Large White or Yorkshire—Numerically the most popular breed in Britain. Colour should be all white. Ears long, thin, slightly inclined forward and fringed with hair. Head moderately long, face slightly dished, snout broad, not too much turned up, jowl light, wide between the ears. Most widely distributed breed in the world. Used pure for production of Wiltshire baconers and crossed with other long breeds to produce commercial baconers.

Large Black—Black in colour with long, thin, lop-ears well inclined over the face. Breed Society first established in 1899. A popular breed for grazing and as a consumer of poorer quality foods. Constitution and skin suited particularly to thrive in both hot and cold climates. Produces good baconers when crossed with the Large White.

Wessex Saddleback—A long sturdily built breed with lop-ears not quite so pendulous as the Large Black. The ideal colour marking is black except for a continuous belt of white over the shoulders and fore-legs. This pattern not yet genetically fixed and some all-blacks occur. Records of numbers born and reared exceptionally good. Sows are good mothers and the breed does well under very rough conditions.

Essex Saddleback—Colour markings are similar to Wessex Saddleback but the white saddle is usually wider and clearer, and there should in addition be white on both hind feet and the tip of the tail. Whole black colour occurs as in the case of Wessex Saddleback. Skin and bone somewhat finer than Wessex Saddleback. Produces good baconers either pure or crossed.

Berkshire—One of the oldest British breeds. Originally black, red and white in colour. The typical colour pattern now consists of an all-black body with white on all four feet, tip of tail and snout. Mature animals are smaller than the bacon breeds but breed is much earlier maturing. Carcases carry high proportion of lean to bone, but if fed to heavy weights, or over-fed with meal, carcases may carry too much fat in spite of proportion of lean. A good grazing pig and popular where pork is required and where climate is hot. First cross with Large White usually all white in colour.

Tamworth—A breed of medium size, long, lean and golden red in colour. Longer in the snout than any other British breed. Carcases less liable to be over-fat than other breeds though not so rapid growing as others. Good for crossing with other bacon type or pork type breeds.

Middle White—An early maturing type of the original Yorkshire White pig. Developed from the Large White and the now extinct Small White breed. Shows more influence of the White Chinese blood than any other British breed. Most early maturing type and suitable for small pork production but can produce baconers when crossed with Large White.

Gloucestershire Old Spots—A medium sized, general purpose type with a few large black spots on a white ground. A sturdily made pig which may grow strong on good land though on limestone the breed may show greater fineness. Capable of running out all the year round on heavy land without fear of hoof damage or rheumatism and well suited to woodland foraging.

Welsh—An all-white long lop-eared pig with good hams. Has been called the British Landrace because of its similarity to the Danish breed. The lop-ears facilitate good grazing habits and the colour and conformation meet the requirements for bacon. Pedigrees have been registered since 1918.

National Long White Lop-Eared—Breed Society founded in 1921, though breed popular in the Tavistock district of Devonshire and neighbouring parts of Cornwall for many years. Though rather more a dual purpose pig, somewhat similar to Welsh breed and amalgamated with that Society from 1926 to 1928.

Other Breeds—Other breeds of less importance numerically include the Ulster Large White, Lincolnshire Curly Coat and the Cumberland pig.

Weights—When referring to the weights of pigs, it is important to make it clear whether it is the live weight or the dead weight that is concerned. There is, of course, no difference between the total weight of an animal alive or dead, but the expression " dead weight " is used to mean the weight of the carcase after it has been eviscerated. In the contracts of the Pigs Marketing Board dead weight was defined as being " the weight (after the animal heat has departed) of a dressed carcase including the skin, the head with the tongue, the kidneys, the tender loins, the fleck or flare, the tail, the backbone and the feet." Where a pig was weighed before the animal heat had departed, the scale of deduction for shrinkage from hot to cold dead weight was :—

Dead weight (hot)	Shrinkage lb.
Up to 9 sc. 9 lb.	4
9 sc. 9 lb. to 10 sc. 15 lb.	5
Over 10 sc. 15 lb.	6

Offals are normally divided into primary offals and secondary offals. The first, not included with the carcase, are the blood, pluck (including lungs, heart, liver, œsophagus and trachea), abdominal contents (including stomach, intestines, spleen), bladder and mesenteric fat. In cattle and sheep the primary offals include head, feet, tail and skin which in the case of these animals are often referred to as the fifth quarter. Secondary offals are those parts of the carcase which are removed when the two sides are being prepared for manufacturing into bacon. These include head, feet, tail, fillet, kidneys, flare fat, bones and trimmings. When the weight of a pig is being referred to, this is sometimes stated as the live weight, but occasionally it is given as the estimated dead weight, and it is important that the method of description should be made clear. Live weights are commonly given in scores of 20 lb. or stones of 14 lb., though they are preferably expressed in pounds. In the case of dead weights these are usually given in scores when killed at bacon factories, and stones of 14 lb. if killed at local butchers. The Ministry of Food commonly now gives all prices in scores. There was originally a Smithfield stone of 8 lb. but its use is now illegal. (For every 14 lb. live weight of an average bullock one could expect to get 8 lb. carcase weight.)

TABLE 81

Carcase Judging

The scale of points adopted for both pork and bacon under the Smithfield method (Davidson, Hammond, Swain and Wright) was as follows :—

	Marks	
	Porkers	Baconers
1. Marketing points :—		
Colour—clean, fresh, white	5	5
Skin—smooth and fine	5	
Dressing—freedom from bruises and hair	5	5
	15	10
2. Breeders' points :—		
(*a*) By Inspection :		
Hams—well filled and fine boned	8	8
Shoulders—light	7	7
Streak—thick, full of lean meat	12	12
(*b*) By Measurement :		
" Eye muscle " of Loin—thick	28	28
Back Fat thickness—correct proportion	20	20
Body Length—in proportion to weight	20	20
Leg Length—short	5	5
	100	100
3. Suitability of Carcase Weight	—	15
Total Marks	115	125

TABLE 82
RATIONING TABLE

		Meal consumption per head per day (as lb. of dry meal equivalent)	Nutritive Ratio
BREEDING PIGS—			
In-pig sows		2–6	1 : 4½–5½
Suckling sows		8–12	1 : 4½–5½
Stock boars		3–7	1 : 4½–5½
FEEDING PIGS—			
Age in weeks	Approx. Live Weight lb.		
3–8	30	1¼	
8	30	1½	
9	32	1¾	1 : 4–5
10	38	2	
11	43	2¼	
12	50	2½	
13	57	2¾	
14	64	3	1 : 5–6
15	73	3¼	
16	81	3½	
17	90	3¾	
18	98	4	1 : 6–7
19	106	4¼	
20	116	4½	
21	124	4¾	
22	134	5	
23	143	5¼	
24	154	5½	
25	163	5¾	1 : 7–8
26	172	6	
27	181	6	
28	190	6	
29	199	6	
30	208	6	

TABLE 83

APPROXIMATE CARCASE DRESSING PERCENTAGES

(All figures are approximate estimates based on average figures obtained in practice from pigs of bacon type fed largely on concentrates. Live weights taken before morning feed, i.e., after about 14 hours' fast. Dead weights taken cold when carcase had reached room temperature.) (H. R. Davidson.)

Live Weight lb.	Carcase Weight lb.	Carcase Dressing Percentage
81	50	61·7
90	58	64·4
98	65	66·3
106	72	67·9
116	80	69·0
124	87	70·0
134	95	71·0
143	102	71·4
154	111	72·0
164	119	72·7
173	126	72·9
184	135	73·4
195	144	73·8
207	154	74·4
220	165	75·0
231	176	76·2
241	185	76·8
251	195	77·6
263	206	78·3
272	215	79·0
282	226	80·0
291	237	81·5

SPECIMEN CARCASE ANALYSIS—The following analysis can be taken as a guide to the approximate weights likely to be obtained from an average quality pig of 200 lb. live weight. The percentages will vary materially for pigs of lighter or heavier weights.

The weight of trimmings may vary considerably according to the method of cutting adopted, and if sides are boned for rolling this will have an obvious effect.

TABLE 84

TOTAL WEIGHT					APPROX. PERCENTAGE OF LIVE WEIGHT
Primary Offals	lb.	oz.	lb.	oz.	
Blood	7	0			
Thymus (sweetbread)		5			
Diaphragm		14			
Lungs and trachea ...	1	7			
Heart		9			
Liver	4	12			
Spleen		3½			
Pancreas		4			
Kidneys		13			
Flare fat	3	6			
Caul fat (omentum) ...		5			
Gut fat (mesentery) ...	2	5	22	3½	11·1
Oesophagus		2			
Stomach empty ...	1	1			
Intestines empty ...	5	8			
			6	11	3·4
Hooves and hair ...	1	4			
Gall bag, bladder, etc.		6			
			1	10	0·8
Loss, intestinal content, evaporation, etc. ...	19	7½			
			19	7½	9·7
Cold carcase, ex kidneys and flare ...	150	0	150	0	75·0
Totals ...			200	0	100·0
Secondary Offals					
Head, ex tongue ...	13	12			
Tongue		12			
Fillets	1	8			
Trimmings, fat and tail	5	4			
Bones and trotters ...	8	12			
			30	0	15·0
Two dressed sides, prepared for cutting and curing			120	0	60·0

TABLE 85
PROPORTION AND VALUES OF CUTS IN A GOOD QUALITY WILTSHIRE SIDE
(H. R. Davidson)

Cut	Weight lb.	Per cent. of total weight
Gammon hock	8·7	15·6
Corner gammon	4·4	7·9
Long loin	3·2	5·7
Short back	4·3	7·7
Rib back	8·8	15·8
Flank	2·6	4·6
Thin streaky	2·8	5·0
Thick streaky	5·2	9·3
Collar	7·3	13·0
Fore hock...	8·6	15·4
Gammon	13·1	23·5
Middle	26·9	48·1
Fore end	15·9	28·4

TABLE 86
ANALYSIS OF SMALL PORKER CARCASE
(H. R. Davidson)

Cut (both sides)	Weight lb.		Per cent. of total weight
	lb.	oz.	
Leg	18	0	24·6
Loin	13	12	18·8
Neck (spare-rib)	16	0	21·8
Belly or streak	10	12	14·7
Spring (including hand)	7	12	10·6
Head	7	0	9·5
Total ...	73	4	100·0

Live weight ... ... 109 lb.
Carcase weight ... ... 73 lb.
Dressing percentage . . 66·9 per cent.

Names of Pigs—Young pigs before they are weaned are referred to as sucking pigs and the sows as suckling sows. For a few weeks after weaning, pigs of both sexes are known as weaners. Castrated male pigs are referred to as hogs or barrows. Maiden female pigs are called gilts, yelts, yilts or hilts. Female breeding pigs are usually referred to as gilts until their first litter has been weaned, after which they are called sows. Uncastrated males are known as boars, and female pigs which have had the ovaries removed are referred to as having been spayed. A male pig castrated after having served is referred to as a stag or a brawner. Small thriftless sucking pigs are known variously as dolly, Anthony sharger or runt pigs.

Breeding Management—Gilts should be served for the first time when they are eight to ten months old. Boars may be used for service at the same age but should be sparingly used until they are 11 to 12 months old. Sows come in season approximately every 21 days and remain on heat for from one to three days. Sows will normally farrow about 115 days after service. Boar pigs should be castrated at six weeks of age and the whole litter weaned at eight weeks of age. When this is done it should be possible for the sow to have two litters within 12 months. The best months in Western Europe for farrowing are March and September. Breeding sows should receive as much exercise as possible, but should be placed in their farrowing pen one week before due to farrow. Warmth in the farrowing pen is essential.

Feeding—Sucking pigs will start to eat solid feed at three weeks old and should be given a highly digestible ration behind a creep. From then until the pigs are about 12 weeks old the food should contain little fibre but plenty of protein and minerals. Barley meal, flaked maize, middlings, with milk by-products, meat and bone meal or fish meal are the best ingredients for young pigs. In later stages of fattening protein and minerals may be reduced. Bacon pigs should increase from one to two pounds live weight per day according to age.

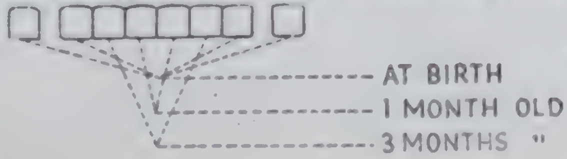
DENTAL FORMULA OF A FULL MOUTH

P.M.	T.M.	C.	I.	C.	T.M.	P.M.
3/3	3/3—1/1	1/1	3/3 | 3/3	1/1	1/1—3/3	3/3—44

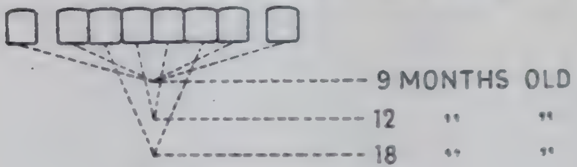
Fig. 12

TEETH AS INDICATIVE OF AGE

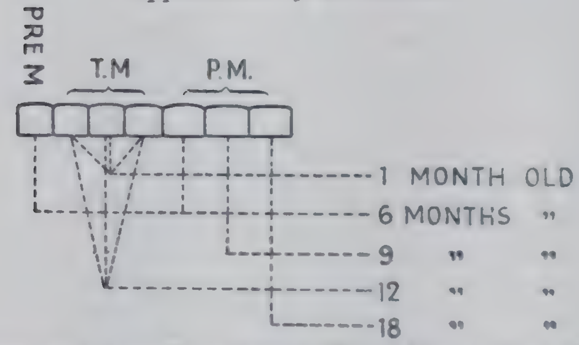
Appearance of the Temporary Incisors and Tusks



Appearance of Permanent Incisors and Tusks



Appearance of the Molars



Regulations of the Smithfield Club Regarding Dentition

Pigs having their corner permanent incisors cut will be considered as exceeding six months.

Pigs having their permanent tusks more than half up will be considered as exceeding nine months.

Pigs having their central permanent incisors up and any of the first three permanent molars cut will be considered as exceeding 12 months.

Pigs having their lateral temporary incisors shed and the permanents appearing, will be considered as exceeding 15 months.

Pigs having their lateral permanent incisors fully up will be considered as exceeding 18 months.

BREEDS OF SHEEP

The breeds of sheep are not nearly so uniform nor are they so distinct one from another as is commonly supposed. In every breed there is an ideal, embodied in accepted flock book characters and sometimes more minutely detailed on breed score-cards, and only individual sheep approaching this breed ideal are exhibited at shows or pedigree sales.

In all flocks some animals deviate from the flock book ideal and are castrated if male or culled if female, in both cases finding an early disposal in the fat market. Again, separate breeds of sheep may so differ in appearance as to suggest different species of animal—compare the Southdown with the Wiltshire Horn, for example—but others, intermediate in type, tend to iron out these extremes, so that the sheep breeds of the world, arranged in appropriate series, show endless and almost continuous gradations in size, type, general appearance and wool characteristics. Nor is any breed of sheep static. Breeds are always changing, sometimes for better, sometimes for worse. These changes occur more rapidly and more frequently than is commonly presumed, being due most frequently, perhaps, to crossing with some other breed. Many breeds—the English Oxford and Suffolk Downs, the New Zealand Corriedale, the Australian Polwarth are recognised examples—originated from the crossing of other breeds and the subsequent prolonged in-breeding and culling of the cross-breds thus secured, until uniformity of type was finally obtained. In fact, practically every breed is, to a greater or less extent, mongrel in its origin, although several, of course, have been kept pure bred for centuries.

Again, whenever a sheep breed becomes widely spread, particularly where its range extends over a wide variety of country and of husbandry conditions, the breed tends to split into separate types which may, eventually, become separate breeds. That fact is certainly due, in part, to different aims in breeders' selection in different areas of a widespread breed territory. To what extent it is due to the more direct effects of climate, soil and feeding on successive generations of sheep, is a question that cannot, at present, be dogmatically answered. It is a question on which Russian scientists hold views diametrically opposed to those of scientists in most other countries of the world. The evidence suggests that although differences in climate, soil and pasture have effects clearly evident upon individual sheep, they do not affect the breed as a whole, apart from the influence that these environmental factors must have upon both natural and artificial selection. It should be quite clear, however, in this as in all other scientific matters, that theory must rest upon the available evidence. At any time new evidence may necessitate a revision of theory.

It is impossible to attempt even a summarised description of all the sheep breeds in the world. British sheep breeds or those like the Merino which are of outstanding importance in the world's sheep industry only are described.

Hill Breeds—To-day, the hill breeds constitute the greater part of Britain's sheep population and from these breeds the lowland sheep of Britain are being increasingly derived. The northernmost counties of Scotland—Caithness and Sutherland—contain the **North Country Cheviot**

established as a separate breed with its own Flock Book as recently as 1946. Cheviots came first to these Scottish counties at the end of the eighteenth century and have remained there ever since. Introduced from the Border districts of South Scotland and North England they have diverged during the course of over a century and a half first into a separate type and finally into a separate breed. The North Country Cheviot is a bigger, heavier, and altogether more massive and less graceful sheep than its modern Border cousin. Within recent years the North Country Cheviot has invaded its country of origin, and many North Country Cheviot flocks are now to be found in the Cheviot hills.

Between Sutherland and the Cheviots, the **Scottish Blackface** is the characteristic hill breed. Horned in both sexes, with a rough and hairy fleece, this breed is one of the hardiest in Britain. It is particularly well suited to heather grazings. Not only in Scotland, but in limited areas of North England, Wales, and Northern Ireland, even down to Dartmoor in Devon, wherever heather is extensive, the Scottish Blackface is likely to be found. In Northern England, however, it has within the last few years lost a great deal of ground to its near cousin, the **Swaledale.**

The Scottish Blackface, largely because of the enormously wide diversity of habitat embraced within its territory, is also rather diverse in character, particularly in fleece character.

Many flocks of Scottish Blackface are found on the Border hills, but the typical breed of that country is the Cheviot. The Cheviot of the Western Border differs somewhat from that of the Eastern, and it is in the latter region that the North Country Cheviot invasion has been mainly felt.

In North England, from East to West, there is an interesting variety of hill breeds. Both Scottish Blackface and Border Cheviot are found, but the most popular breed is the Swaledale which has spread enormously within the last 30 years. Closely related to the Scottish Blackface, it is leggier, more rangy, and carries a lighter fleece. It has a characteristically "mealy" nose and an interesting fleece, showing signs of the fine woolly undervest and coarser and more hairy outer jacket of most wild sheep breeds. Westwards across North England there is the **Rough Fell**, even more closely akin to the Scottish Blackface than the Swaledale and finally the little white-faced, horned, and rough-coated **Herdwick**, regarded by many as the hardiest of the hill breeds.

On the mountain spine running down to the Peak through the centre of England there existed many local breeds, some of them now reputed extinct. Among these is the **Lonk**, the

Derbyshire Gritstone, the **Limestone** and the **Penistone** of which only the two first survive in any numbers.

In the Welsh hills the **Welsh Mountain** remains supreme. This is Britain's smallest sheep and also one of the most active. The ewes are very good milkers. The breed is white or tan-faced, hornless in ewes, strongly horned in rams. It bears a fine and close fleece, inclining to kempiness, kemp being white, thick, dead fibres found among the true wool, particularly on the britch. The Welsh Mountain, both as regards numbers and the range it covers, is one of the most important breeds in Britain.

On the isolated hill country of south-west England, in Devon and Cornwall, there are several local breeds in addition to invading Scottish Blackfaces and Cheviots. Of these local breeds, the **Exmoor Horn** and the **Dartmoor** are best known.

All hill breeds provide appreciable amounts of wool and mutton. Within modern times, however, their main use has been to provide store sheep stock for the adjacent lowlands; wether lambs for fattening, and ewe stock—ewe lambs, young ewes, or more commonly cast-for-age ewes—for further breeding. The term cast-for-age means that once a ewe is five or six years old, depending on district, she becomes too old for a hill flock, although she may have two or more useful breeding seasons on lowland farms. Wether hill lambs are fattened for slaughter.

Longwools—The Longwool breeds were once the most valued in England being noted for their great weight of long, coarse-fibred wool. In medieval times, this English longwool was unique in character and indispensable for many kinds of woollen manufacture and brought great wealth to the country. Until the latter half of the eighteenth century all Longwool breeds were kept to serve two purposes—to clip the heaviest possible fleece, and to consolidate and manure the arable land on which they were folded. For both purposes a massive, weighty sheep was needed and some of these old Longwools grew to immense sizes. Their mutton qualities were mostly disregarded, until Robert Bakewell, of Dishley Grange, near Loughborough, began to improve the mutton qualities of the Longwool breed of his native Leicester. Bakewell had two purposes in view—to fatten his sheep more easily and at an earlier age. In both aims he succeeded, largely by in-breeding and progeny testing, methods novel to his age. Bakewell's NEW OR IMPROVED LEICESTER was used for crossing, at one time or another and to a varying extent, with all the other Longwool breeds of England. Several of these, named after their counties or districts of origin, achieved world distribution and fame. Nevertheless, within their native country and within recent years they have suffered a considerable decline both in numbers and importance. The most famous of these English Longwool breeds are the LINCOLN, the KENT OR ROMNEY MARSH, the LEICESTER, the DEVON LONGWOOL, the BORDER LEICESTER and the WENSLEYDALE.

The **Lincoln** is a breed of particular historical interest. This is one of the heaviest sheep breeds in the world and carries the heaviest fleece. In former times it was even more weighty. The world importance of the Lincoln was based upon crossing with the Merino. When meat refrigeration, introduced about 1880, led to an international commerce in frozen mutton, the Lincoln was one of the English breeds most widely used to cross with the Merino ewe in order to improve the mutton qualities of the lambs. Moreover, the long wool of the Lincoln and the fine wool of the Merino blended well, retaining many of the valuable textile qualities of both. Two of the most important dual-purpose sheep breeds of the Southern Hemisphere—the CORRIEDALE and the POLWARTH—were founded on the Lincoln × Merino cross.

The **Kent or Romney Marsh** is regarded as the most typical breed in many districts of New Zealand, particularly in the North Island. New Zealand breeders have greatly modified it, however, paying particular attention to fleece improvement, with the result that the New Zealand Romney is best regarded now as a separate and distinct breed. In England the Romney is still an important breed in the Romney Marshes, where it is used to graze the lush summer vegetation found in that unique area. Probably no other breed is better suited to heavy stocking on marshy land.

The **Leicester,** the first English Longwool breed to be improved for its mutton qualities, and used subsequently to impart such qualities to other Longwool breeds, has not had the same influence on the world's sheep as have the Lincoln and Romney Marsh. Reduced in numbers, it is now found in England mainly on the Yorkshire Wolds and, apart from its name, has lost all connection with its county of origin.

The **Devon Longwool,** although a useful sheep, has never spread far beyond its native county.

All these Longwool English breeds have greatly decreased in both numbers and importance within recent times. Apart from specialised ram-breeding flocks, largely dependent upon an export trade, they are no longer a typical feature of the mixed husbandry of lowland England. For export they have lost a good deal of importance through the development of their dual-purpose derivatives out of the Merino. The Longwool breeds have a magnificent historical past but a somewhat problematical future.

At least two Longwool breeds, however, the **Border Leicester** and the **Wensleydale**, are in a more secure position because they are widely used for crossing with hill breeds. In Scotland the Border Leicester is extensively used for this purpose alone. The first-cross with the Cheviot is the **Scottish Half-Bred**, probably at its best, the ideal ewe for lowland temporary leys. The first-cross with the Blackface, called the **Greyface** or **Cross ewe**, is another useful sheep for lowland grazings. The Border Leicester also yields a good cross with both Herdwick and Welsh Mountain.

The Wensleydale, in the North of England, is used for much the same purpose as the Border Leicester in Scotland. Crossed with the Swaledale it produces the **Mule** or **Masham Cross**. Sheep breeders in the North of England are, however, rather more inclined to experiment with change of breed than is common in most other districts of Britain. Recently, another breed, the **Blue-headed** or **Hexham Leicester** has tended to replace both the Border Leicester and the Wensleydale for crossing with the dark-faced hill breeds of the North. This Blue-headed Leicester is said to be an ancient breed of local origin, but its appearance rather suggests it to be a cross between Wensleydale and Border Leicester. In any case, it is a Longwool breed of increasing popularity.

The various crosses by Longwool rams out of hill ewes promise to become the predominant type of sheep on the temporary grasslands of lowland Britain. Their only serious competitors in England are two recently established breeds well suited to grassland farming, the Kerry Hill (Wales) and the Clun Forest. Both breeds originated on the English-Welsh border, and show clearly the Welsh Mountain ancestry. Although pure bred, they retain many of the valuable qualities of independence, foraging ability, hardiness, milkiness and prolificacy characteristic of the first crosses out of hill ewes. The Kerry Hill is a very attractive looking sheep with clearly defined black and white face markings. The Clun, a breed of ever-increasing popularity, resembles an in-bred cross between the Welsh Mountain and the Shropshire Down. It must be emphasised, however, that while both Kerry Hill and Clun were probably formed by crossing a variety of lowland breeds, and perhaps other hill breeds, on the Welsh Mountain, with subsequent in-breeding and culling of the crosses, both breeds are now firmly established as separate pure breeds with their own Flock Books and Breed Associations.

Shortwools—Many flocks of Longwools already described were kept under the old English folding system, but even more typical of the folded flock were the Down breeds of which there is also a wide variety.

Down sheep are **Shortwools**, and the distinction between Longwools and Shortwools goes back to the earliest records of English sheep history. The Shortwool grows a typically short, fine fleece of light or medium weight, contrasted with the long, coarse, heavy fleece of the Longwool breeds. As the name indicates, Down sheep had their origin in the sheep that grazed the Downs, and historically speaking, by far the most important of these was the breed that grazed the Southdown commons.

The **Southdown** was the first of the Down breeds to be improved towards better mutton conformation and earlier maturity. It was, in fact, the first English Shortwool to be cast into a modern shape. John Ellman, of Glynde, in Sussex, first made the attempt towards the end of the eighteenth century and his success was outstanding, the Southdown to this day being the butcher's ideal. The Southdown to-day is seldom, if ever, kept for the commercial production of mutton or of wool. Its purpose is to provide rams to pass on its superb mutton qualities to the fat lambs out of ewes of other sheep breeds. When quality of carcase is at a premium then, to give the final top-cross in fat lamb production, the Southdown has no serious rival. In times of meat scarcity, however, as in those of to-day, the Southdown suffers in competition with other Down breeds which produce a larger, and faster growing, if less perfect cross lamb.

There are many such Down breeds. Just as Bakewell's Improved Leicester was used to improve the mutton qualities of all the Longwools, so Ellman's Southdown was used on all the local breeds and varieties of Shortwools. The **Suffolk** originated in a cross—in the first instance an accidental cross—between the Southdown and the ancient horned heath breed of Norfolk ; the **Shropshire Down** by crossing the Southdown with the old heath breeds of Cannock Chase ; the **Hampshire Down** by crossing with the original Shortwool breed of that county. The **Dorset Down**, very similar to the Hampshire, owes even more to the Southdown. The **Oxford Down** has an origin rather different from the other Down breeds, having a great deal of Longwool—actually Cotswold Longwool—in its ancestry. It was founded as late as 1830 by the crossing of Hampshire rams on Cotswold ewes and by in-breeding the progeny.

The **Ryeland**, although white-faced in contrast to the dark-faced Down breeds, also owed much to the Southdown in its later history.

The **Dorset Horn**, a horned, white-faced Shortwool, stands rather apart from the other breeds of English sheep. It has a much more extended mating season and for this reason has been widely used for breeding out-of-season fat lambs. Some say it shows evidence of admixture with the Merino, which also has an extended mating season.

The **Merino** was at one time quite widely distributed in Britain and round about 1800 many experiments were made in its acclimatisation. Indeed, there are suggestions of there having been Merino sheep in England before Elizabethan times. There were in any case some noted Merino flocks in England far into the nineteenth century. The disappearance of the Merino from the English scene was due to English sheep-breeders, about 1800, turning their attention to mutton rather than to wool. The Merino, unrivalled for the quality and fineness of its wool, is not regarded as a mutton sheep. This fact and the importation of more cheaply produced fine wool from newer continents and countries caused the eclipse of the Merino in Britain.

SHEEP BREEDING—Crossing is more prevalent in the breeding of sheep than in any other class of farm animal. The bulk of the world's sheep are cross-bred which is not the same as being mongrel. Cross-bred sheep are the result of carefully planned breeding systems ; mongrels are the climax in a series of haphazard matings. The prevalence of cross-breeding in sheep is due to several causes. Cross-breeding results in hybrid vigour, which means that the first cross between two distinct breeds is usually a better and more productive animal than either of its parents. This hybrid vigour vanishes when the first-crosses are in-bred, probably one reason why the first-cross is so widely used in commercial sheep farming.

Again, by a system of crossing, it is possible to secure a quick adaptation of sheep to pasture or arable conditions. For example, hill sheep are best fitted to the semi-natural conditions of mountain grazings. By crossing with a Longwool, the first-cross is suitable for cultivated pastures.

Crossing, moreover, tends to take advantage of the nutritional inequality of the natural seasons. To take a Scottish example, on the best class of heather covered hills, Blackface ewes are customarily mated with Border Leicester rams rather than with rams of their own breed. Such hills are suited only to Blackface sheep during winter, but in summer the pasture is fit to support something more productive. By crossing Blackface ewes with the bigger and more rapidly maturing Border Leicester, a cross lamb able to take full advantage of summer's bounty is secured.

Finally, crossing is the best method of obtaining an economical compromise between pastoral conditions and market requirements. Thus, while the Southdown undoubtedly provides the best mutton or lamb carcase, it would seldom if ever be profitable to maintain a flock for this purpose alone. The Southdown is rather delicate, is neither particularly milky nor prolific and under most pastoral conditions another breed or cross would thrive better. Thus the Southdown has become a ram-producing breed. Crossed with say Welsh Mountain or New Zealand Romney ewes the Southdown imparts much of its own mutton qualities to the progeny.

The advantages obtained by crossing may be carried into out-breeding within a breed. In many parts of the world—the Australian plains, the Scottish Highland hills—it is customary to bring rams from stud flocks in more fertile areas to " improve " as the saying goes, the range flocks of more barren grazings. The practice has the obvious danger of importing strains of sheep—either Merinos in Australia or Blackfaces in the Scottish Highlands—too delicate for the range conditions their descendants must withstand. But the practice is so widespread in sheep husbandry that the compensating advantages must be considered. One such possibility is that when two different strains of the same breed of sheep are mated together, a certain degree of hybrid vigour may result.

Sheep of most British breeds—the Dorset Horn being the only important exception—have a definite mating season extending from autumn to spring. Ewes of these breeds will not take the ram during the summer months. Although the Dorset Horn is the only British breed which mates with any certainty during summer, there are many other breeds throughout the world that do, of which the Merino is the most widespread and important. Even in these breeds, however, there seems to be a slackening in the intensity of mating during the summer. Long hours of sunlight inhibit the ductless gland secretions on which the sexual behaviour of the sheep depends.

Ewes of most British breeds come into heat during late August or September. Heat in the ewe is not nearly so obvious as in the cow, and without the presence of rams it is usually impossible to tell which ewes are in heat. A ewe in heat gives off an odour that attracts the ram. The heat period is variable, extending on the average over about 30 hours. If the ewe is not put in lamb she continues to come in heat at intervals of about 16 days until the following spring. If conception occurs at mating, however, she does not come in heat again that season and lambs after an interval of about five months, more exactly from 142-152 days, the average being 147 days.

A ewe may bear a single lamb or twins, twin births being much more frequent than they are in cattle. Triplets are quite frequent, and four, five or even more lambs at a birth are on record. In general, single lambs under range conditions and twins where husbandry is more intensive prove most profitable.

Fertility in sheep varies between individuals and between breeds. It is also greatly influenced by management. In general the better the pastoral conditions the more fertile the ewes, although it is possible for them to be too fat for breeding. When ewes are let down in condition before the mating season —" tupping time "—and then, by better feeding, brought into rapidly improving condition to meet the rams, " flushing effect " is secured. " Flushing " ewes in this way raises their fertility, mainly by increasing the number of twins conceived. Fertility increases with age of the ewes up to about four or five years, after which it begins to decline.

The early progress of lambs depends upon the milking ability of the ewes. As with fertility, milk yield in sheep varies as between individuals and between breeds. Considering it is of prime importance to the growth of lambs, knowledge of milk yield in ewes is scanty. As with dairy cows, " steaming up " before lambing by providing more and better food, leads to increased growth of the udder and a higher milk yield. After lambing the milk yield of the ewe depends upon her feed, changes in the condition of the pasture quickly affecting the milk yield of the ewe and in consequence the growth and bloom of her lamb. Ewes nursing twins give rather more milk than those nursing singles, a fact probably due to the greater number of times the ewe is milked daily.

In former times, indeed even to-day in the more primitive peasant communities of Europe and Asia, the sheep is used as a dairy animal, chiefly to supply cheese. Certain luxury brands of modern cheese are made from ewes' milk. As to quantity, most unspecialised sheep breeds average 20-30 gallons per lactation, milk yield in sheep as in cattle, being considerably lower in the first lactation. Merino sheep, generally regarded as poor milkers, average about 21 gallons per lactation. In certain sheep breeds, specially bred for their dairy qualities, yields are much higher. Thus the East Friesian milch sheep yields over 100 gallons. Ewes' milk is richer than cows' milk, with a butter-fat percentage of 5.8 per cent. or even higher.

In sheep as in most other animals, the sexes are born in almost equal numbers. Whereas the majority of ewes are kept for breeding, the vast majority of male sheep are castrated as lambs, the castrated male sheep being called a *wether*. Wether sheep are used for the production of mutton or wool.

or both. On the most barren sheep grazings, wethers can sometimes be kept profitably under conditions where, because of altitude, drought, exposure or poor pastures, any attempt at breeding would meet with certain failure. Under modern conditions of sheep husbandry, however, the great majority of wether lambs are slaughtered before they are one year old.

Male sheep left uncastrated or entire are used for breeding purposes. They are called *rams* or tups. The breeding and bringing out of rams for sale is usually left in the hands of specialist sheep breeders. The rams are most often pure-bred and pedigreed and the main purpose of these ram-breeding flocks is to sell rams. Ram-breeding flocks are often called "stud" flocks. The ambition of a ram-breeder is to sell outstanding rams at high prices for use in other stud flocks. Less outstanding rams are sold to breeders aiming at mutton and wool production; these breeders being frequently called commercial sheep-breeders. Rams sold to commercial sheep-breeders, usually at more moderate prices, are used for mating with ewes of the same or different breed.

While rams are capable of sexual activity at most seasons of the year, there being no definite rutting season in sheep as there is in deer, the ram is usually most sexually active at the season ewes are in heat; in most British breeds between autumn and spring. Hot weather definitely reduces their activity and may render them temporarily sterile. A ram under range conditions is usually allowed 30-60 ewes. Where ewes in heat are brought in to the ram, he may serve 100.

Artificial insemination has been used in sheep-breeding, particularly in Russia. The technique is closely similar to that widely employed in the dairy industry, the main difference being that, in sheep, teasers or vasectomised rams are required to detect ewes that are in heat. Teasers are rams of small value with an apron tied under them. Teasers follow and jump on ewes that are in heat but, because of the apron, cannot serve them. Vasectomised rams are those in which the vasa-deferentia, the tubes through which the semen pass from testicles to penis, have been severed. Vasectomised rams behave in every way like normal rams, but are sterile. On the whole, A.I. in sheep does not seem to offer the same commercial advantages as it does in dairy cattle.

SHEEP PRODUCTS—The main saleable products of the sheep industry are mutton and wool. In some countries, Australia and South Africa for example, the main emphasis is on wool. In Britain, for more than a century, mutton has been of far more economic importance. New Zealand has achieved a nice balance in which the values of wool and mutton produced are roughly equal.

Mutton is less popular than beef as an article of diet and its consumption is confined mainly to sheep-breeding countries. As an article of international commerce the only really important market is the British Isles. Within the last 50 years, there has been a trend to slaughter sheep at ever younger ages and at ever lighter weights. In fact, lamb rather than mutton, has become the most important and lucrative product of sheep-farming.

Wool remains the most important textile fibre for use as human clothing in temperate and cold climates. There are nowadays, however, many substitutes. Cotton, rayon, nylon and other types of artificial fibre closely resembling wool in their physical properties, have achieved increasing popularity. The effect of these substitutes has been to lower the price and limit the profitability of natural wool production. Nevertheless, particularly during wars and following wars, the growing of the finer types of wool still pays.

Not all sheep grow wool. Indeed, only half the world's sheep are wool-bearing. In Britain, the Wiltshire Horn breed grows no true wool. All other British breeds grow a fleece of some kind, the wool of different breeds being put to very different purposes.

Wool, considered as a raw material of the textile industry, may be divided into three main classes—

(1) Fine or Merino wools.
(2) Cross-bred wools.
(3) Carpet wools.

The finest and most valuable wool still comes off the Merino sheep. The term cross-bred does not imply that the sheep from which the wool is shorn are necessarily cross-bred. It means that while the wool has not the fine quality of Merino wool, it can still be used for weaving cloth. The great majority of British breeds grow cross-bred wool. In many breeds, particularly Eastern, the wool is too coarse and hair-like for use in cloth making. It has, however, an especial value in the making of carpets and rugs. Several British hill breeds, Blackface, Swaledale and Herdwick for example, produce carpet wools.

In the case of Merino and Cross-bred fleeces it has become customary to assess the fineness of the wool on a conventional range of figures called the Bradford Count. On this scale, the very finest Merino wools are classed as 100's or over. Most Merino wool is rather coarser, say 60's to 80's. The majority of cross-bred wools are classed in the 50's. Coarse longwools, such as Lincoln, may have a spinning count as low as 30's-40's. As well as fineness expressed in the spinning count, length of staple, soundness of fibre, yield and colour, are all important qualities in assessing the manufacturing value of wool. A staple length of about two inches is required for the worsted trade, the most valuable branch of the wool textile industry. Soundness means that the fibre can be woven without risk of breakage. In some wool samples there is a point of weakness, called the break, in the fibres, due to malnutrition or sickness of the sheep at the time the weak section of the fibre has been grown. Yield expresses the proportion by weight of a fleece which is true wool. The fleece of every sheep when shorn contains a variable quantity of grease, dried sweat, and extraneous dirt. When the fleece is scoured, all this foreign matter is washed out of the wool, and the weight of clean wool expressed as a percentage of the unscoured fleece is called the yield. Some wools, particularly those from some strains of fine-wooled Merinos, contain so much grease or yolk that the yield is little more than 50 per cent.

The term colour as applied to wool means brightness and lustre. Dingy, stained, or discoloured wools will not take the lighter and brighter dyes satisfactorily, with a consequent decrease in value.

Cheese—In addition to mutton and wool, dairy produce, particularly cheese, is, in some countries, still an important product of sheep farming. At one time the sheep was used much more extensively as a dairy animal than it is to-day. In Britain nowadays, sheep are very seldom milked, although in earlier times ewe-milking was common practice in all pastoral areas of this country.

One Eastern breed of sheep, the KARAKUL, has the distinction of supplying a product of value and importance to the fur trade. New-born Karakul lambs have a birth coat of tight curls, and these lamb skins are used to make the furs known as Persian and Astrakan lamb.

SHEEP HUSBANDRY—Sheep can be kept profitably under the most diverse conditions of husbandry. At one extreme is extensive sheep farming, where only one sheep may be grazed on a number of acres. This is typical of most dry or hilly sheep districts all over the world. The pasture is usually natural and uncultivated, the land cheaply rented, and the sheep live under semi-natural conditions. In Britain hill sheep farming is of this type and its success depends very largely on giving the sheep plenty of space to roam and find a living. When sheep do well there is always a temptation to increase stocking, and overstocking is, perhaps, the most common error in hill sheep farming. That statement is particularly true of common grazings. Heavy mortality among hill sheep is often nothing more than Nature's method of correcting overstocking.

Attempts to stock sheep closely on permanent pasture of any kind usually fails. The ground quickly becomes " sheep-sick " owing to the accumulation of sheep parasites and disease germs. These results of close-stocking on permanent pasture are more quickly evident when sheep are grazed alone without cattle.

On temporary leys sheep farming can safely become much more intensive. Stocking can be reckoned in sheep to the acre rather than in acres to a sheep. Fat lamb production from prolific and deep-milking ewes grazing good temporary leys is probably the most profitable system of sheep husbandry practised to-day.

The Folding System, in which the flock, closely concentrated, is confined between hurdles on specially grown arable crops was, until quite recently, the most common method of keeping sheep throughout lowland England. The system is falling into disuse, mainly owing to increased labour costs and the expansion both of dairying and grain growing in lowland areas. The Folding System was, nevertheless, an excellent method of keeping sheep, excellent both for the sheep and the land. It is, therefore, possible that were cheaper methods of temporary fencing devised, some revival of the Folding System might occur. The present indications are, however, that the most probable pattern of future sheep farming in Britain starts with the hill breeds. Crosses derived from these hill breeds will be used to stock temporary leys on lowland farms. These cross ewes on temporary leys will again be crossed by rams of a Down breed to give the type of fat lamb the modern consumer prefers. In aiming towards the final product—the Down cross " milk " lamb—other saleable produce of the country's sheep industry cannot be safely neglected. The wether side of both the hill flocks themselves and of their Longwool first crosses have to be sold for slaughter. Wool, even faced as it is to-day with the increased use of artificial fibre, should be something more than a mere by-product. The sheep industry, if it is to survive the competition of other forms of animal husbandry, must produce readily saleable produce at every stage of its carefully graded descent from mountain to plain.

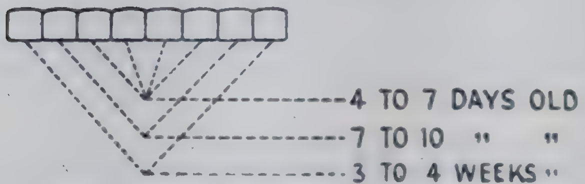
DENTAL FORMULA FOR A FULL MOUTH.

P.M.	T.M.	INC.	T.M.	P.M.	
3/3	3/3	0/4 | 0/4	3/3	3/3	= 32

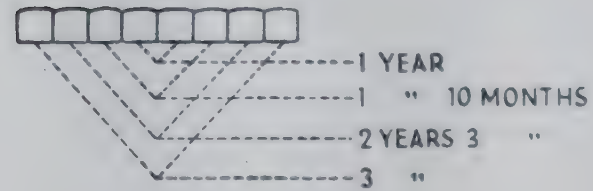
Fig. 13

TEETH AS INDICATIVE OF AGE.

Appearance of Temporary Incisors.


4 TO 7 DAYS OLD
7 TO 10 " "
3 TO 4 WEEKS "

Appearance of Permanent Incisors.


1 YEAR
1 " 10 MONTHS
2 YEARS 3 "
3 "

Appearance of Molars.

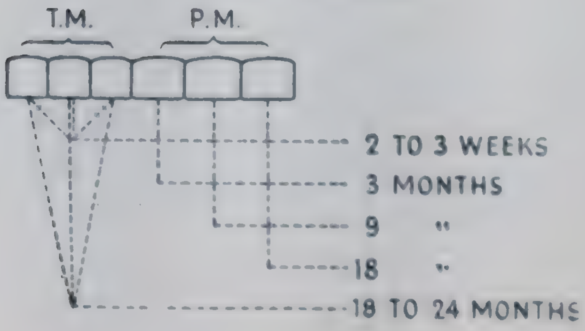

T.M.
P.M.
2 TO 3 WEEKS
3 MONTHS
9 "
18 "
18 TO 24 MONTHS

TABLE 87
AVERAGE NORMAL TEMPERATURE, PULSE AND RESPIRATION

	Temperature (Fahrenheit)	Pulse beats per minute	Respirations per minute
Horses	100·4	34–40	8–12
Cattle	101·3	40–60	12–16
Sheep and Goats	103·0	60–80	20–30
Pigs	102·6	55–75	20–30
Dogs	101·3	70–90	15–25
Cats	100·4	—	—
Rabbits	100·85	—	—
Fowls	106·9	—	—
Small birds ...	108·6	—	—
Elephants (Steel)	97·6	—	—
Camels (Steel) ...	99·5	—	—

TABLE 88—PERIODS OF PUBERTY

	Months
Mare	12–24
Cow	12–18
Sheep	8–12
Goat	8–12
Sow	4–5
Bitch	7–10
Cat	8–12

TABLE 89—ŒSTRUM

Animal	Duration of Oestrum (days)	Return after Parturition	Return if not Impregnated
Mare ..	5–7	7–10 days	2–3 weeks or more
Cow	2–4	21–28 days	3–4 weeks or more
Ewe	1–2	4–6 months	17–20 days
Sow	2–4	5–6 weeks	20–21 days
Bitch ...	7–21	5–6 months	5–6 months
Cat	7–21	Twice yearly but sometimes 3 or 4 times	1–3 weeks but varies

TABLE 90—NUMBER OF FEMALES ALLOWABLE TO EACH MALE

Mares	80	Hens	6–10
Cows	50	Ducks	6–10
Ewes	60	Turkeys	8
Sows	10	Geese	4

TABLE 91—UTERO-GESTATION

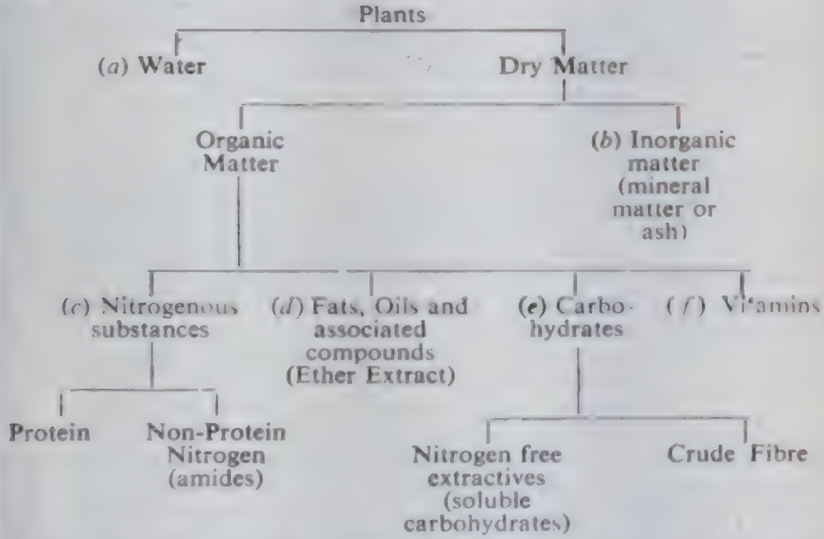
Animal	Average Period	Early Period for Young to Live	Late Period
Mares	335–345 days (11–11⅓ months)	307 days (10 months)	365 days (12 months)
Cows	275–287 days (39–41 weeks)	242 days (34½ weeks)	312 days (44½ weeks)
Sheep and Goats	149–151 days (21–21½ weeks)	140 days (20 weeks)	160 days (23 weeks)
Sows	112–119 days (16–17 weeks)	105 days (15 weeks)	126 days (18 weeks)
Bitches and Guinea Pigs	63 days (9 weeks)	55 days 8 weeks)	70 days (10 weeks)
Cats	55 days (8 weeks)	50 days	64 days
Rabbits	28–30 days (4 weeks)	—	—
Elephants ...	2 years (nearly)	—	—
Zebras	13 months	—	—
Camels	45 weeks	—	—
Ferrets	6 weeks	—	—

ANIMAL NUTRITION

The science of nutrition involves the study of various chemical and physiological processes for the conversion of food constituents to body constituents and products and the provision of energy to bring about this conversion and for the muscular and other activities of the animal.

Plants which almost exclusively furnish the food materials of animals, build up under the influence of sunlight complex compounds from carbon dioxide, water and mineral salts. In the animal these compounds are simplified or broken down to provide body building materials and energy.

The groups of foods occurring in plants may be tabulated thus :


Plants
(*a*) Water
Dry Matter
Organic Matter
(*b*) Inorganic matter (mineral matter or ash)
(*c*) Nitrogenous substances
(*d*) Fats, Oils and associated compounds (Ether Extract)
(*e*) Carbohydrates
(*f*) Vitamins
Protein
Non-Protein Nitrogen (amides)
Nitrogen free extractives (soluble carbohydrates)
Crude Fibre

Animals contain the same substances as plants but the proportions in which they occur are different.

Water is the principal constituent of both plants and animals. In the former it decreases as the plant matures ; in the latter it decreases rapidly in early life and more slowly as maturity is approached. Mature animals have a water content of about 50–60 per cent. the amount present being largely influenced by the nutritional state as shown by the fat stored. Thus a fat animal contains less water than a lean one.

The amount of fat in the animal body varies considerably with the plane of nutrition and, in general, increases with age.

TABLE 92

**Percentage Gross Composition of the Animal Body*
(Less contents of digestive tract)

Species	Water	Protein	Fat	Mineral Matter
Steer	55	17	33	4·6
Pig	58	15	24	2·8
Sheep	60	16	20	3·4
Hen	56	21	19	3·2
Mare	60	17	17	4·5
Man	59	18	18	4·3

* *Maynard, L. "Animal Nutrition," McGraw Hill Book Co.*

There is, in addition about one per cent. of carbohydrate actively concerned in the metabolic processes.

By expressing the composition of the animal body on a fat-free basis, since fat is the most variable constituent, the gross composition of the body in respect of the other constituents becomes less variable and is approximately :

Constituent	per cent.
Water	75
Protein	20
Mineral matter	5

Little variation from these figures is evident after the animal reaches maturity although the water content decreases throughout life. The various groups of chemical substances tend to be localized according to the functions performed, e.g., although water is a constituent of all parts of the body its distribution is variable as shown thus :

	per cent. H_2O
Blood Plasma	90–92
Muscle	72–78
Bone	40–50

The carbohydrate is centred chiefly in the liver, muscles and blood ; proteins are present in the organs and soft body structures such as muscles, tendons and connective tissues, and fats in the adipose tissues, sub-cutaneously, and around the intestines, kidneys and other organs. The mineral matter is also widely distributed the individual minerals being localized according to their function. With the exception of calcium the mineral elements occur as fractions of one per cent. Eighty per cent. of the total body phosphorus is present, combined with calcium, in the skeleton while the remainder is found in association with proteins, fats and inorganic salts. Most of the magnesium is present in the bones, the remainder being widely distributed. Sulphur is present as part of the protein molecule while sodium, potassium and chlorine are found as inorganic salts, sodium and chlorine being inter-cellular and potassium intra-cellular. Although some have been shown to be necessary for life others have no known function.

In plants protein is a constituent of the active tissues hence leaves are richer than stems. With maturity there is a gradual transition of protein from leaf to seed to provide for growth requirements at germination.

Most seeds, e.g., the cereal grains contain carbohydrates as the principal form of reserve energy but in others such as oil seeds fat is the form in which energy is stored. Normally the leaves contain more fat than the stems but the amount is highest in the seeds.

In addition to acting as a reserve material principally as starch, carbohydrate may in the form of cellulose function as a structural or protective element.

The mineral matter (ash) of plants varies with the species, with individual plants of the same species and with the parts of the plant and may be markedly influenced by soil factors. Plants are richer in potassium than in other elements, the amounts of calcium and phosphorus being considerably less. Calcium is associated with the vegetative parts of plants hence leaves are richer than stems. Seeds are the poorest source of calcium although oil seeds contain more than others. In the case of phosphorus, seeds are richer than leaves and leaves are a better source than stems.

Water—As an essential constituent of the animal body water performs a number of important functions—

(*a*) It is a solvent and as such is concerned in the transportation of solutes, including products of metabolism.
(*b*) Large quantities of water are involved in the secretion of saliva during mastication, etc.
(*c*) It is connected with the mechanisms of secretion and excretion.
(*d*) It forms an important constituent of the lubricant of joints and as a cushion for the nervous system.
(*e*) It is associated with the senses of seeing and hearing.
(*f*) Because of its high specific heat it can absorb large quantities of heat for small increases in temperature. This helps to maintain the constancy of the body temperature.
(*g*) Its high latent heat of vaporisation also helps to regulate body temperature. Evaporation from the skin helps to cool the body.

Sources of Water — Most of the water utilised is ingested but metabolism releases further supplies thus: Carbohydrate + oxygen → Carbon dioxide + water.

Fats and proteins also release water in this way. This metabolic water is sufficient to meet the requirements of hibernating animals for water lost in respiration and evaporation.

Water is also required for the formation of tissues during growth and for productive purposes, e.g., milk secretion and egg production.

It is excreted via the urine where it acts as a solvent for such catabolic products as urea and minerals; some is removed from the body in the expired air as water vapour while the remainder is lost in perspiration. The latter loss, via the sweat glands, is a mechanism for the regulation of body temperature since heat is dissipated in the evaporation of water.

Water requirements of animals—The amount required by any animal must be sufficient to balance the losses outlined above and to allow for the formation of new tissues and body products.

It has been shown that milking cows require 4–5 lb. water for each 1 lb. milk produced and it is evident that all livestock should have adequate supplies of water at all times.

The Carbohydrates—This group of foods is widely distributed in plants and, although forming the largest part of the food of animals small amounts of sugars and glycogen only, occur in the animal body.

Carbohydrates are the first products of photosynthesis, a process occurring in green plants whereby with solar energy carbon dioxide and water are chemically combined. They owe their name to the fact that they contain carbon with which is combined hydrogen and oxygen in the same proportions as in water.

Classification of Carbohydrates

I. Sugars

(*a*— Monosaccharides
- (i) Pentoses $C_5H_{10}O_5$
  - Arabinose
  - Xylose
  - Ribose
- (ii) Hexoses $C_6H_{12}O_6$
  - Glucose
  - Fructose
  - Galactose
  - Mannose

II. Non-Sugars

(*a*— Polysaccharides
- (i) Pentosans $(C_5H_8O_4)n$
  - Araban
  - Xylan
- (ii) Hexosans $(C_6H_{10}O_5)n$
  - Starch
  - Glycogen
  - Cellulose
  - Inulin
  - Dextrin

(*b*) Disaccharides $C_{12}H_{22}O_{11}$
Sucrose
Maltose
Lactose

(*c*) Trisaccharides $C_{18}H_{32}O_{16}$
Raffinose

(*b*) Mixed Polysaccharides
Gums
Mucilages
Pectins

The Pentoses—Although found in certain plants these sugars occur chiefly in complex form in the pentosans from which they may be obtained by hydrolysis. Thus arabinose is obtained from the araban of gum arabic ; xylose from the xylan of hay and woody fibre, while ribose is present in certain nucleic acids and the vitamin riboflavin.

The Hexoses—The hexoses form a large group of sugars which occur either as constituents of foods or as products of metabolism and hence are of especial importance in animal nutrition. Glucose (dextrose or grape sugar) and fructose (laevulose or fruit sugar) are present in fruit juice and honey and are the only members of the group to occur free in nature. Galactose is formed from the hydrolysis of lactose (milk sugar).

The Disaccharides—The disaccharides which are of varying solubility in water, result from the condensation of two molecules of hexose monosaccharides. Thus :

$$C_6H_{12}O_6 + C_6H_{12}O_6 = C_{12}H_{22}O_{11} + H_2O$$

Glucose + Fructose = Sucrose
Glucose + Glucose = Maltose
Glucose + Galactose = Lactose

Sucrose or cane sugar is present in sugar cane, sugar beet, ripe fruits and tree sap (maple sugar) and is the source of domestic sugar. It can not be directly absorbed from the intestines and in digestion is broken down to glucose and fructose. The non-crystallisable sugar obtained as a liquor from the refining industry is known as molasses.

Maltose is produced by the hydrolytic action of diastase on starch and, during digestion, is converted into glucose by the enzyme maltase.

Lactose occurs only as a product of the mammary gland and comprises approximately half the solids present in milk. On hydrolysis it yields glucose and galactose, compounds of the latter sugar occurring in the brain and nervous tissue. Lactose which possesses a number of physiological advantages over other sugars is less sweet and less soluble than cane sugar.

Trisaccharides—Raffinose, present in barley, wheat, sugar beet and mangolds yields on hydrolysis fructose, glucose and galactose.

The Polysaccharides—The polysaccharides are polymerised anhydrides (condensation products) of large numbers of simple sugars. They are unreactive substances of high molecular weight and form colloidal solutions. Quantitatively they are the most important group of nutrients in foods of vegetable origin. On hydrolysis the pentosans yield pentose sugars and the hexosans yield hexoses.

Starch forms the reserve material of most plants, the starch granules of different plants varying in size and shape. On hydrolysis by acids or enzymes dextrins, maltose and glucose are successively yielded. It is widely distributed in tubers and cereal grains and gives a characteristic blue colour with iodine. In certain plants, e.g., the Jerusalem artichoke it is replaced as reserve material by inulin which yields fructose on hydrolysis. Glycogen or " animal starch " is present in the liver and muscles. It closely resembles starch in properties and functions and like starch yields glucose on hydrolysis. With iodine it gives a brown coloration.

Cellulose is a structural carbohydrate and as such is associated with lignin in the framework of plants and in the protective coating of seeds. It can be hydrolyzed by strong acids to glucose but it is not acted upon by any enzyme secreted by the digestive systems of mammals. It is however broken down by microorganisms in the digestive tract of certain animals. Lignin, although containing carbon, hydrogen and oxygen, is not a true carbohydrate but it occurs in intimate association with cellulose and is included with carbohydrates in the conventional methods of analysis. It has an aromatic nucleus and exhibits differing degrees of condensation according to the age of the material. The presence of lignin has a considerable influence on the digestibility of certain foods.

Soluble Carbohydrates and Crude Fibre—In the chemical determination of the carbohydrates two groups are recognised (i) Soluble carbohydrates (Nitrogen-free extractives) and (ii) Crude fibre and they appear under these headings in tables showing the gross composition of feeding stuffs.

Soluble carbohydrates include sugars, starch and hemicelluloses ; this fraction is not actually determined but represents the difference between the sum of all other constituents (water, ash, crude protein, ether extract and crude fibre) and 100.

Crude fibre includes cellulose, pentosans, lignin and cutin, (a substance which prevents excessive evaporation of water from, and the entrance of excessively large amounts of water into plants. This fraction is higher in hay and foods classed as " roughages " than in cereal grains. Similarly it is high in milling offals such as bran and other seed or cereal by-products than in the seed or grain as a whole.

Digestion of Carbohydrates—The carbohydrates are broken down into simple sugars by the hydrolytic action of specific enzymes secreted into the digestive tract. Enzymes are proteins, although some also contain a vitamin in their molecule, which are capable of bringing about hydrolysis. They are specific in action and effective over limited pH range. Since starch is the predominant carbohydrate in plant tissues glucose is the chief end product of carbohydrate digestion. The enzyme ptyalin, present in small amounts in the mouths of most farm animals, and in larger amounts in the case of pigs, converts starch into dextrins and then maltose. In the small intestine starch, which has escaped salivary digestion is converted into maltose by amylase. Here also the following changes take place :

Sucrase converts sucrose → glucose + fructose
Maltase ,, maltose → glucose
Lactase ,, lactose → glucose + galactose

Digestion of Crude Fibre—This is brought about by enzymes secreted by symbiotic micro-organisms in the digestive tracts of animals. The rumen of ruminant animals and the caecum and colon of the horse are the principal centres of this activity by which cellulose and pentosans are converted into :

(*a*) gases, e.g., carbon dioxide and methane
(*b*) organic acids, e.g., acetic, lactic, etc.
(*c*) simple sugars.

By this method ruminants can digest about 50 per cent. of the crude fibre of most foods.

The digestibility of the complex polysaccharides decreases with the age of the plant hence the " crude fibre " of fresh or dried pasture grass is more easily digested than that of hay. Digestibility of crude fibre is also lowered by the presence of lignin which is itself indigestible.

Metabolism of the Carbohydrates—Metabolism involves two types of changes : Anabolism—the building up of complex molecules from simple ones and Catabolism—the breakdown of complex into less complex molecules. Catabolic changes, which are often oxidative in character involve the utilisation of oxygen transported by the blood to the tissues from the lungs. The simple sugars (hexoses) which form the end point of carbohydrate digestion pass though the intestinal wall into the blood. In the liver they are built up into glycogen which there forms a reserve of energy. The subsequent utilisation of glycogen involves its conversion to glucose.

When adequate reserves of carbohydrate are present in the liver the surplus blood glucose may be utilised as follows :

(*a*) Converted into glycogen in muscle cells to provide for the energy expended in muscular work,
(*b*) Oxidised in body cells to provide heat for the maintenance of body temperature,

(*c*) In the synthesis of lactose in the mammary gland,
(*d*) Converted into body fat and stored as adipose tissue around the viscera, and in the so-called fat depots.

Function of Carbohydrates—The function of carbohydrates is to produce energy on oxidation, surplus supplies being converted into reserve fat. Unless carbohydrates are present in adequate amount protein, a much more expensive nutrient, is oxidised instead. Furthermore, although much of the crude fibre is indigestible it adds bulk to the ration and thereby satisfies the appetite and stimulates peristalsis. In addition it may assist the digestion of certain concentrated foods which would otherwise tend to form compact " doughy " masses in the stomach impenetrable by the digestive juices.

Glucosides—These substances which contain glucose are important not as nutrients but for their toxic properties, by which plants are provided with protection. Two main types are recognised, Cyanogenetic glucosides and Mustard-oil glucosides.

The former liberate (amongst other products) hydrocyanic acid or prussic acid on hydrolysis. Linseed for example contains the cyanogenetic gluoside linamarin and, when the crushed seed is kept warm and moist the glucoside is hydrolysed yielding prussic acid. Care must therefore be taken in the preparation of linseed gruels to use boiling water or to boil the gruel for about 10 minutes.

Glucosides of the second type contain an irritant, allyl isothiocyanate—" essential oil of mustard "—and occur in black and white mustard seeds. While the whole seeds may pass through the digestive tract without harmful effect yet, as crushed impurities in cakes, they have proved toxic.

The Fats and Oils—Fats and oils which belong to a wider group called the lipides, are widely distributed in plants and animals and represent quantitatively the most important constituent of the animal body. They are insoluble in water with which they form emulsions, but soluble in ether, chloroform and benzene, solvents which, in the conventional analysis of food, are responsible for the removal of related compounds such as sterols, etc. For this reason the extracted material is spoken of as " crude fat " or " ether extract."

The fats and oils are compounds of glycerol (glycerine) with various fatty acids such as stearic, palmitic and oleic. There is no essential difference between fats and oils, the term oil being applied to a fat which is liquid at ordinary temperatures. Certain oils may in fact solidify to fats in winter.

Fats contain carbon, hydrogen and oxygen but the amount of oxygen present in the molecule is relatively small, e.g., tripalmitin $C_{51} H_{98} O_6$ and triolein $C_{57} H_{104} O_6$.

The molecules of the fatty acids present in the harder fats contain relatively more hydrogen than those of the softer fats. The former are called "saturated" and the latter "unsaturated fatty acids." Fat consistency therefore depends on the nature and proportions of the fatty acids present since these have different melting points.

Comparatively hard fats such as beef and mutton fat contain palmitic and stearic acids with melting points of 63°C and 70°C while softer fats such as lard and butter have a higher proportion of unsaturated fatty acids, i.e., acids which are liquid at ordinary temperatures. Butter frequently becomes more oily when cows first go out to graze in spring due to an increase in the amount of oleic and linoleic acids consumed. Linseed, rape and other oils contain a high proportion of oleic acid so that stall fed animals receiving large quantities of such cakes as linseed and rape may produce butter of an oily consistency. Conversely palm oil, a constituent of palm kernel cake produces a firm butter by reason of its content of palmitic acid.

Uses of fats—Oils from oleaginous seeds used in the preparation of cattle cakes, and fats unfit for human consumption (from slaughter houses) are hydrolysed into glycerol and soap by heating with caustic soda or caustic potash. The process, which is known as saponification, is important in the manufacture of soap.

Margarine making involves the catalytic hydrogenation of mixtures of vegetable and animal fats to increase the degree of saturation of the fatty acids and produce a harder product. The vitamin content is then increased to the same standard as that of good butter.

Iodine Number—In the same way that hydrogen can be catalytically added to the unsaturated fatty acids so also can iodine be used to saturate fatty acids. Thus the weight of iodine which can be absorbed by a given weight of fat provides a useful measure of the character of that fat. Foods which contain fats or oils with a high proportion of unsaturated fatty acids will tend to produce soft carcase fat, e.g., soya bean oil has an iodine value of 130 and soya beans give rise to very soft bacon fat. A change of diet, involving a change from foods rich in unsaturated fats to foods rich in saturated fats causes a modification of the carcase fat deposited.

The following table shows the influence of the type of fat fed on the character of the body fat.

TABLE 93

Food fat	Iodine Number of food fat	Iodine Number of body fat
Soya bean oil ...	132	123
Corn oil	124	114
Cotton seed oil ...	108	107
Peanut oil	102	98
Lard	63	72
Butter fat	36	56
Coconut oil ...	8	35

(Maynard L., Animal Nutrition, McGraw Hill Co.)

In addition to the Iodine Value there are a number of other constants the difference in values of which afford means for the identification of oils and which are of assistance in detecting adulteration, e.g., the adulteration of butter with margarine containing vegetable oils.

Rancidity—Small amounts of free fatty acids may be present in foods particularly in immature, growing plants. Foods which have been stored in a damp condition or which have absorbed moisture on storage tend to undergo certain changes which result in the development of unpleasant odours and tastes, i.e., they become rancid.

While the development of rancidity may be oxidative in character it can also be caused by certain fungi and micro-organisms. Usually it involves the hydrolysis of fats and oils, by the enzyme lipase, with the production of free fatty acids. Butter becomes markedly rancid after only mild hydrolysis. The comparative ease with which rancidity can develop emphasises the need for careful storage of animal foods containing fat or oil.

Digestion of Fat—The acidity of the stomach, due to the presence of hydrochloric acid helps to release fatty constituents of foods from their coverings. Fats are saponified and emulsified by the action of the alkaline bile salts and undergo hydrolysis by pancreatic lipase with the formation of fatty acids and glycerol.

Certain other lipides, known as phospho-lipides, contain a phosphoric acid group and also have nitrogen as one of their constituents. Their importance lies in their being fat soluble and having an affinity for water. They are thought, therefore, to be responsible for the transportation of fat.

Metabolism of Fats—The products of fat digestion pass through the walls of the small intestine into the lymphatic system and thence into the blood.

Absorption involves the release of the fatty acids from water soluble complexes with the bile salts and their combination with glycerol, while passing through the absorbing cells, to give neutral fat.

After absorption the neutral fat may be utilised catabolically to provide energy as heat for the maintenance of body temperature and as energy for the performance of muscular activities, e.g., work.

Anabolically it may be converted into milk fat whilst surplus amounts are stored in the adipose tissues together with fat produced from ingested carbohydrates.

Approximately one half of the adipose tissue is found subcutaneously, the remainder being present around certain organs such as the kidneys and in the muscles.

The end points of fat catabolism are carbon dioxide and water which are excreted via the lungs, kidneys and skin.

Function of Fats and Oils—The main function of fats and oils is the provision of energy. Since they contain less oxygen in their molecules than either carbohydrates or protein they require very much more oxygen to bring about complete oxidation and therefore yield more energy. Fat yields, weight for weight about 2.3 times as much energy as carbohydrate.

While animals have the ability to synthesize fats from carbohydrates a dietary deficiency of fat lowers the digestibility of the ration. A minimum fat intake is essential for health and growth but excessive amounts are incompletely digested and the fatty acids produced act as irritants.

Certain oils, e.g., halibut liver and cod liver oils are also of importance since they contain vitamins A and D which are also present in butter fat.

The Proteins—Protein is the principal constituent of the organs and soft body structures and food protein represents the only source of tissue protein. It is therefore essential that dietary deficiencies do not occur.

Composition of Proteins—The factor which distinguishes proteins from fats and carbohydrates is the high and fairly constant nitrogen content.

The composition of protein is expressed thus :—

	per cent.
Carbon	51–55
Hydrogen	6–8
Oxygen	21–24
Nitrogen	15–18
Sulphur	0·3–2·5
Phosphorus	0·1–1·5

Proteins are complex substances which form colloidal solutions, while some are insoluble. Because of their complexity their classification is based on physical rather than chemical characteristics.

They are built up of units, called amino-acids, of which about 25 are known, 22 occurring in typical food proteins. Their properties depend on the numbers, arrangement and nature of the amino-acids present.

Classification

I. SIMPLE PROTEINS—

(*a*) Albumins—egg albumin, lactalbumin (milk), wheat leucosin, etc.
(*b*) Globulins—lactoglobulin, legumin of peas and beans, etc.
(*c*) Glutelins—wheat glutenin and oryzenin of rice.
(*d*) Prolamins—plant proteins, e.g., zein (maize), hordein (barley).
(*e*) Scleroproteins—Skeletal structures and protective tissues, e.g., ossein (bone), collagen of hoofs, horns and feathers.
(*f*) Protamines—simplest form of proteins and present in sperm.
(*g*) Histones—of animal origin ; haemoglobin is a typical histone.

II. CONJUGATED PROTEINS—

(*a*) Phosphoproteins—caseinogen (milk) or ovo-vitellin (egg yolk). Phosphoproteins form the principal part of the food protein of young mammals and avian embryos.
(*b*) Chromoproteins—proteins combined with a coloured group, e.g., the protein globin combines with haematin to produce haemoglobin.
(*c*) Glucoproteins—proteins containing a carbohydrate group, e.g., mucins (saliva).
(*d*) Lecithoproteins—protein combined with lecithin, e.g., fibrinogen of tissues.
(*e*) Nucleoproteins—protein combined with nucleic acids and characteristic of cell nuclei.

III. DERIVED PROTEINS—

Simpler in character than the proteins from which they are produced by hydrolysis.

Primary derivatives—

(i) Proteins—casein of curdled milk.
(ii) Metaproteins—result from further hydrolysis.
(iii) Coagulated proteins—insoluble and formed by the action of alcohol or heat on the protein or its solution, e.g., egg albumin.

Secondary Derivatives—

(i) Proteoses
(ii) Peptones
(iii) Peptides

Produced by further hydrolysis, all water soluble but not heat coagulable.

Digestion of Proteins—In the acid conditions of the stomach, produced by hydrochloric acid, protein is partially hydrolysed to proteoses and peptones by the proteolytic enzyme pepsin which functions most efficiently at pH 2·0. On entering the small intestine pancreatic juice (pH 8), containing the enzyme trypsin, further hydrolyses protein to proteoses or polypeptides. The intestinal juice, which is an alkaline fluid of pH 7·7, contains a number of enzymes collectively known as peptidases and formerly thought to be a single enzyme erepsin which complete the digestion of protein by hydrolysing polypeptides to amino-acids.

Nucleoprotein first undergoes gastric digestion with the formation of protein and nuclein while the latter product undergoes tryptic digestion to form protein and nucleic acids. Nucleic acids are fermented by a number of enzymes present in the intestinal juice with the eventual production of hexose and pentose sugars, phosphoric acid and purine and pyrimidine bases.

Protein Metabolism—The amino-acids resulting from protein digestion are absorbed and transported by the blood to the tissues where they may be re-synthesized to restore tissue waste, to build up body protein during growth, or for the formation of the protein of a body product such as milk or wool. Glandular secretions such as hormones require amino-acids for their formation. Amino-acids unsuitable for use synthetically or in excess of the body's requirement are deaminized, i.e., nitrogen is removed as ammonia, and the non-nitrogenous residue oxidized and used as a source of energy. The ammonia is excreted as urea in the urine. The pentose and hexose sugars, resulting from the digestion of nucleo-protein, enter into carbohydrate metabolism.

Function of Proteins—The main function of the proteins is to provide the means whereby body tissues, body coverings and body products may be built up and the ability of food protein to meet these requirements depends qualitatively and quantitatively upon the nature and types of its amino-acid constituents. The ability of an animal to synthesize amino-acids for protein building is limited hence the lack of particular amino-acids which the animal needs but is unable to synthesize restricts the utilisation of food protein.

Indispensable Amino-acids—Amino-acids which can not be synthesized or which can not be synthesized sufficiently rapidly to meet the needs of the animal, must be present as constituents of food protein and are known as essential or indispensable amino-acids. They include lysine, tryptophane, histidine, arginine, valine, leucine, isoleucine, threonine, methionine and phenylalanine which are essential for growth.

Certain amino-acids, although normally regarded as non-essential may in certain conditions become essential, e.g., when another amino-acid is either present in small amounts or absent from the diet.

Proteins which contain all the indispensable amino-acids are called first-class proteins and have high biological values. These include all animal proteins, with the exception of gelatin, and a number of plant proteins. Most plant proteins are incomplete, i.e., they are deficient in one or more of the essential amino-acids. It is therefore important that animals on strictly herbivorous diets should receive protein from a variety of sources. It is known that the feeding of animal proteins, e.g., skim milk increases the value of cereal proteins when they are fed together.

The efficiency or biological value of a protein is its capacity to meet the requirements of the tissues ; it may be expressed thus :

$$\text{Biological Value} = \frac{\text{Nitrogen used anabolically}}{\text{Nitrogen absorbed}} \times 100 \text{ p.c.}$$

True Protein and Crude Protein—In addition to proteins animals and their food contain simpler nitrogenous substances such as peptides, amino-acids, ammonium salts, nitrates, etc. collectively referred to as "amides." The crude protein of feeding stuffs which is found by determining the total nitrogen content and multiplying by 6·25* thus includes non-protein nitrogen. According to the concept of true protein this non-protein or "amide" nitrogen is regarded as making no contribution to protein nutrition, yet amino-acids and peptides are equally as valuable as though actually part of the protein molecule. It is known, furthermore, that amide, nitrate and ammoniacal nitrogen may contribute to the protein nutrition of ruminants by bacterial synthesis in the rumen.

The distinction between crude and true protein has lost much of its significance by a recognition of the fact that the value of protein depends upon its "quality" i.e., upon the kinds and amounts of amino-acids present in it. Thus true protein has not the definite nutritive value which it was formerly thought to possess. The value of the "amide" fraction has long been recognised in the United States of America and hence crude protein is taken as the true measure of the value of a food in protein nutrition. Owing to the high solubility of the "amide" fraction and its consequent rapid passage through the alimentary tract it may not however be so efficient as protein nitrogen. In Great Britain its effectiveness as protein is assessed at 50 per cent. hence the protein value of a food may be expressed by the protein equivalent (P.E.) thus :

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* While individual proteins vary in their nitrogen content it is usual to adopt a standard of 16 per cent. Hence protein can be calculated by multiplying total N by $\frac{100}{16}$, i.e., N x 6·25.

$$\text{P.E.} = \frac{\text{Digestible Crude Protein} + \text{Digestible True Protein}}{2}$$

The Mineral Constituents—The inorganic elements which, in the conventional analysis of feeding stuffs are represented by "ash," occur in inorganic and organic combination. Elements which perform essential functions in the body and which consequently must form part of the animal's food are calcium, phosphorus, sodium, potassium, chlorine, magnesium, iron, sulphur, iodine, manganese, copper, cobalt and zinc. Of these essential elements calcium, phosphorus sodium, potassium, magnesium, iron, sulphur and chlorine are required in comparatively large amounts ; the remainder which are needed only in small quantities are known as "trace elements".

Other elements occurring in the animal body, the dietary need for which has not yet been proven, are fluorine, silicon, boron, bromine, arsenic, selenium, etc. These may be present simply because they are constituents of food ; some are definitely harmful.

Functions—Compounds of these elements are essential for the formation of bones and teeth and give strength and rigidity to skeletal structures. They are necessary also for the formation of blood and other body fluids the pH and osmotic pressure of which they regulate. They are constituents of muscles, organs and other soft tissues, and are concerned in the relaxation and contraction of the heart muscle. Some elements are actively concerned in metabolism and in the control of the metabolic rate. Growth, fattening and production of body products involve the utilisation of mineral elements. The percentages of the more important mineral constituents of the body are shown below :

Table 94

Element	per cent.	Element	per cent.
Calcium	1·33	Chlorine	0·11
Phosphorus	0·74	Magnesium	0·04
Sodium	0·16	Sulphur	0·15
Potassium	0·19		

Certain of the elements are inter-related and may conveniently be described together.

Calcium and Phosphorus—Together these elements form 90 per cent. of the ash weight of the animal body, about 98 per cent. of the calcium and 80 per cent. of the phosphorus being present in the bones and teeth, probably as hydroxy apatite $3\ Ca_3(PO_4)_2 \cdot Ca(OH)_2$ or carbonate apatite $3\ Ca_3(PO_4)_2 . CaCO_3$. Bones contain about 50 per cent. water, 5 per cent. fat, 20 per cent. protein and 25 per cent. ash while bone ash is composed of approximately 85 per cent. tri-calcium phosphate, 14 per cent. calcium carbonate and about 1 per cent. magnesium phosphate.

Although there may be slight varations with age and diet, calcium and phosphorus usually occur in a 2 : 1 ratio.

Calcium salts are also essential for the clotting of blood, the level of blood calcium being regulated by a hormone secreted by the para-thyroid gland. Calcium also plays a part in the clotting of milk. Phosphorus is a constituent of the blood and of nucleoproteins and has an important role in carbohydrate metabolism.

The growth of bone involves the conversion of cartilage to protein (ossein) which is mineralised chiefly by calcium and phosphorus.

Milk contains large quantities of these elements and, when the demand for them, e.g., during pregnancy or lactation is great supplies are supplemented by withdrawing them from the spongy bones. Demineralisation of the spongy bone can occur without harmful effect and, when the demand for calcium and phosphorus decreases, e.g., as lactation declines, the bones are re-mineralised. When, in the adult animal, a dietary deficiency of these elements occurs in combination with a vitamin D deficiency even the compact bone may become involved. If the deficiency persists the bones lose rigidity and osteomalacia develops. In young animals deficiencies of calcium and phosphorus or vitamin D retard the development and mineralisation of bones and lead to rickets. Milk fever in dairy cows, the result of a fall in the level of blood calcium which may occur at the beginning of a lactation, is cured by the injection of soluble calcium and magnesium salts.

The ability of farm foods to meet the animal's requirement of these elements differs ; roughages are rich in calcium but poor in phosphorus while the reverse is the case with cereal grains. Pastures differ widely in their content of these elements but good pastures, especially those containing leguminous plants, are useful sources.

While adequate amounts of calcium and phosphorus in foods are necessary the proportions in which they are present is at least as important. A ratio of about 1–2 Ca : 1 P and most probably 1·5 Ca : 1 P appears to be the optimum, any marked variation from these figures leads to a disturbance of their absorption.

Sodium, Potassium and Chlorine—Compounds of these elements are found almost entirely in the soft tissues and blood. The body contains about 0·2 per cent. sodium, chiefly in extra-cellular fluids, and slightly less potassium. Sodium which forms over 90 per cent. of the bases present in blood serum is not stored in the body to any extent and is eliminated in the urine, as chloride or phosphate, and in perspiration.

Deficiency of sodium results in retarded growth and inability to make full use of digested carbohydrate and protein.

Foods of animal origin are better sources of sodium than those of plant origin while the reverse is true of potassium. Hence a dietary deficiency of potassium is unlikely to occur. Compounds of potassium occur in intra-cellular fluids; with sodium they function in muscle metabolism.

Chlorine, which comprises about 65 per cent. of the acidic ions of the blood is stored in the skin and also subcutaneously. Chlorides are of importance as hydrochloric acid in the gastric juice and occur in adequate amounts in most vegetable and animal foods with the exception of the cereal grains and their products.

Although poultry and pigs show low tolerance to sodium chloride (salt), their diets, which consist largely of cereal grains or their by-products, may occasionally require to be supplemented. Because of the amounts of sodium and chlorine in milk dairy cows may require an additional supply. These supplements may be given as mixtures incorporated with the food or as " licks."

Magnesium—This element is present in all herbage and is widely distributed in the animal body where it is present mainly in the skeleton with smaller amounts in the blood plasma. It is concerned in the formation of bones and teeth; it activates the enzyme phosphatase and functions in carbohydrate metabolism. It is related metabolically to calcium and phosphorus and magnesium deficiency may result in a disturbance of calcium metabolism. While dietary deficiencies of magnesium are unlikely to occur, experimentally induced deficiencies result in death. Lactation or grass tetany in cows and sheep follows a rapid fall in blood magnesium. Symptoms resemble those of milk fever and treatment is similar i.e., by injection of calcium and magnesium chlorides, magnesium sulphate or calcium gluconate.

Iron, Copper and Cobalt—These elements occur in the body in very small amounts; the iron content is about 0·005 per cent. while copper and cobalt are present in traces. Iron is a constituent of the haemoglobin of red corpuscles which are concerned with oxygen transportation; it also catalyses cellular oxidation processes. Copper, though not a constituent of haemoglobin is concerned in its formation; it occurs in blood and liver. It functions as a catalyst in cellular oxidation—reduction reactions and occurs as copper-protein compounds, e.g., haemocuprein in the blood and hepatocuprein in the liver of mammals.

Deficiencies of iron or copper result in a lowered haemoglobin content of the blood, a condition known as nutritional anaemia. Though this condition may arise at any time it is most common during the suckling period. The iron and copper contents of milk are low and young animals have to depend on the reserves laid down in their bodies before birth. Colostrum contains approximately 17 times as much iron as normal milk and thus represents an invaluable supply to the calf. The livers of calves at birth contain much more copper than do those of adult animals, a supply probably sufficient for the young animal until weaning. Iron deficiency in young pigs may be cured by giving them access to turfs, by dosing with ferrous (iron) and copper sulphates or by painting the sow's udder with a syrup containing these salts in solution. Mud, with which the sow's udder occasionally becomes covered is alone often sufficient to prevent the onset of anaemia.

Copper deficiency in Great Britain results in a condition in sheep known as " swayback," which may prove fatal.

Cobalt deficiency causes "pining" in sheep, and "bush sickness" or " Pines " in New Zealand and Australia probably by interfering with iron metabolism. The animals suffer from anæmia and become markedly emaciated, but small amounts of cobalt salts are effective as preventatives or curatives. They may be administered orally as in licks or the amount in the herbage increased by dressing the pastures with 2 lb. cobalt sulphate (or chloride) per acre.

While some plants are relatively poor in iron, pulse crops, cereals and especially milling offals, and greens are satisfactory sources.

Iodine—The amount present in the body is small. It is present mainly as thyroxine, a hormone secreted by the thyroid gland. Thyroxine controls the basal metabolism of the body and a deficiency results in retarded physical, mental and sexual development. When iodine is deficient enlargement of the thyroid gland takes place, i.e., a simple goitre results.

The young of iodine deficient animals are either born dead or in a weak condition; iodine deficiency causes " hairlessness " in pigs. Goitre is not entirely the result of iodine deficiency but may be caused by a factor or factors which inhibit iodine metabolism. Although iodine is present in small amounts in all green foods certain crops namely cabbage and kale are goitrogenic, i.e., they tend to cause goitre when fed in excessive amounts.

Manganese—In the animal body manganese is present in practically all tissues and is stored mainly in the liver and kidneys. It functions in connection with reproduction, lactation and growth and is probably involved in tissue respiration.

Zinc—Zinc is widely distributed in small amounts in animal tissues and milk contains about 3 mg. per litre with rather more present in colostrum. While it is a dietary necessity for rats, its absence causing retarded growth and poor fur development, no deficiency has been recorded amongst farm animals. It is probably concerned in carbohydrate metabolism.

Sulphur—Sulphur is chiefly present as a constituent of the amino-acids cystine and methionine although it occurs as sulphate in the blood and in the hormone insulin.

Elements which may prove toxic

Fluorine—Fluorine is a constituent of bones and may be partially responsible for the hardness of teeth. A deficiency is believed to hasten dental decay. Fluorine, when present above certain concentrations may prove toxic, and produces a mottling of the enamel of teeth. Mineral supplements, e.g., rock phosphate, water, or soil may contain fluorine in excessive amounts.

Arsenic—Arsenic is an extremely toxic element and its use against insect and fungal attack increases the risk to livestock.

Copper—As already noted the presence of copper in small amounts is a dietary necessity; in higher concentrations it is toxic.

Selenium—" Alkali " disease, and a more acute form " Blind Staggers " are the result of excessive intakes of selenium in all classes of livestock. The herbage of certain areas of the United States of America contains harmful amounts of this element. Symptoms of the disease are loss of appetite, emaciation and anæmia; in acute cases, depraved appetite, blindness, paralysis and death.

Molybdenum—This trace element is present in relatively large amounts in certain Somerset pastures where it causes " teart " a condition manifest by severe scouring. Dairy cattle in particular lose condition rapidly. The administration of copper sulphate (1–2 g/day) cures the condition. Molybdenum toxicity is associated with calcareous soils and lime and manures containing lime ncrease the molybdenum absorbed, while the reverse is true of acidic fertilisers. The application of cobalt salts in cobalt deficient areas has been found to increase the molybdenum absorption by plants to a dangerously high level.

The Vitamins—Vitamins are essential organic components of a complete diet. Although chemically they do not constitute a single class of compounds they are related by their potency and pronounced physiological effects. They have, like enzymes, specific functions but show in addition functional relationships to each other. For example sterility may be caused by deficiencies of vitamins A or E ; bone formation is influenced by A, C and D ; A, B_2, D and E are concerned in growth while not only A but C also is a disease resistance vitamin.

The vitamins are divided into two groups according to their preferential solubility in fat or water. Those which are fat soluble are A, D, E and K and those which are water soluble include B and C.

Vitamin A ($C_{20}H_{29}OH$), which is essential for normal growth and which increases the resistance of the body to disease, is found in halibut and cod liver oils with Vitamin D ; it is present in the livers of farm animals which, however, contain only small amounts of vitamin D. Other useful sources of the vitamin are egg yolk, milk, colostrum and butter fat in which the amount present is dependent on the amount in the animals' food. Although vitamin A is not present in plants as such, the green parts of plants contain a number of pigments called carotenoids which can be converted by hydrolysis into vitamin A in the liver of animals. Not all the carotene undergoes conversion, for part passes unchanged into the milk of lactating animals and part may be stored in the tissues. The extent to which carotene is converted into vitamin A varies with the breed of cow, Channel Island breeds converting much less than others with the result that the fat and milk of these breeds is a deeper colour.

Deficiency of vitamin A in the young animal leads to a cessation of growth. In adult animals it increases susceptibility to bacterial infections of the respiratory, alimentary and genito-urinary systems. Where deficiency is acute, xerophthalmia an inflammatory condition of the eyes may develop. Vitamin A and the carotenes are susceptible to heat and oxidation and must therefore be stored away from air, heat and light. For these reasons losses in haymaking are considerable. The artificial drying of grass reduces these losses by the rapidity of drying, compactness of baling with exclusion of air and subsequent storage under cover. Well made silage contains adequate supplies of carotene but root crops, except carrots, are poor. Since vitamin A is stored in the liver, deficiencies do not develop immediately but only after prolonged inadequacy in the diet.

Vitamin D which is multiple in character and includes D_2 or calciferol ($C_{28}H_{44}O$) and D_3 ($C_{27}H_{44}O$) accompanies vitamin A in natural oils and fats. Its distribution is limited, plants are devoid of the vitamin and animals have a limited capacity for storing it but fish liver oils, egg yolk and butter fat are good sources.

Vitamins D_2 and D_3 are produced by the irradiation of certain sterols with ultra-violet light. In the case of farm animals ergosterol, present in the skin, is converted by sunlight into calciferol, the name of which is derived from its association with calcium and phosphorus metabolism.

An absence of vitamin D results in imperfect calcification of bones and teeth even in the presence of calcium and phosphorus in the correct proportions and in adequate amounts. Rickets in the young animal or osteomalacia in the adult may be cured by sunlight and the activation of ergosterol or by the addition of cod liver oil to the food. Hence D is known as the anti-rachitic vitamin. Exposure of the food to sunlight may also be sufficient to produce an adequate supply of the vitamin.

The vitamin D potency of milk is variable and it contains approximately ten times as much in summer as in winter though at no time does it contain sufficient to prevent rickets. Hence the importance of sunlight and or cod liver oil to the young animal.

While it is practically absent from growing plants, the drying of crops in sunlight, as in haymaking, causes the development of small amounts. The feeding of cacao-shell meal which is a useful source of vitamin D supplements the vitamin D potency of the ration of stall-fed dairy cows. Care must be taken to avoid feeding excessive amounts of cacao-shells since fermentation produces a toxic principle, theobromine.

Vitamin E ($C_{29}H_{50}O_2$) is associated with reproduction and its deficiency causes sterility in both sexes of certain animals. It is not strictly the anti-sterility vitamin since its provision will not cure forms of sterility resulting from other causes, e.g., deficiencies of other vitamins or inorganic elements.

It is widely distributed in farm foods and green plants such as spinach and lettuce contain satisfactory amounts. The oils of seed embryos, e.g., maize and wheat germ oils are especially good sources ; it is also present in animal products although milk contains very little. Its widespread distribution is probably sufficient to ensure adequate supplies in the rations of farm animals.

Vitamin K ($C_{31}H_{46}O_2$) is widely distributed in animal foods particularly in green plants and is also present in egg yolk and liver.

It is concerned with the formation of prothrombin in the liver and its absence from mammalian diet leads to a failure of the blood clotting mechanism due to a lowered blood content of prothrombin.

Vitamin K can be synthesized by bacteria in the intestine and rumen. Since it is widely distributed in foods and can be synthesized by ruminants deficiencies of this vitamin are unlikely to occur.

Vitamin B which is multiple in character, is the most widely distributed of all the vitamins. The numerous factors which make up the vitamin B complex have specific functions and occur in the outer coats of seeds and in seed embryos, in green plants, fruit, milk and yeasts. Manufacturing processes, e.g., milling and polishing, which result in the removal of the seed coats consequently remove the vitamins and hence, milling offals may be useful sources. Since the vitamin is so widely distributed deficiencies should seldom occur ; that ruminants can synthesize these factors is an additional safeguard.

Vitamin B_1 ($C_{12}H_{17}ON_4SClHCl$) now known as aneurin and formerly as thiamin occurs in the seed coats of cereal grains and is thus present in milling offals. It is present also in brewer's yeast, the germ of cereals, plant leaves and in such animal products as egg yolk, liver, heart and kidneys. It can be synthesized in the rumen.

A deficiency of this vitamin causes diseases which affect the central nervous system, e.g., beri-beri in man and avian polyneuritis. These diseases are characterised by retarded growth and nervous disorders and, in extreme cases, paralysis and death. It is also believed that aneurin functions in connection with carbohydrate metabolism.

Its wide distribution amongst animal foods combined with the ability of ruminants to synthesize it indicates that general shortages of B_1 are unlikely to occur although deficiencies may arise in the cases of non-ruminants and young animals.

Vitamin B_2 ($C_{17}H_{20}O_6N_4$) is known as riboflavin or lactoflavin. It occurs in such animal products as milk, whey, egg white, liver, heart, brain, etc., and in green leafy forage crops. Cereals and cereal grains are poor sources of this vitamin which can also be synthesized in the rumen.

Riboflavin is a growth-promoting factor and is a constituent as a coenzyme in a number of enzyme systems in which it is concerned with oxidation mechanisms in the body.

Although not required by ruminants it is necessary for other classes of animals including poultry. Its absence results in retarded growth, paralysis and death, but adequate amounts are usually present.

Vitamin B_6 ($C_8H_{11}O_3N$) is known as adermin. It occurs in yeast, cereal grains and especially in grain by-products, vegetable fats, liver and milk. Adermin is concerned in the formation of hæmoglobin and in the metabolism of amino-acids. While no known deficiency has occurred in cattle and sheep its absence causes dermatitis in rats, a reduced growth rate in pigs and nervous degeneration in chicks.

Vitamin B_7 ($C_6H_5O_2N$), nicotinic acid or niacin, is known as the "pellagra prevention" factor. It is widely distributed in plants and animals and may be present as the amide, e.g., in liver, yeast and wheat germ. It can be synthesized by ruminants but for pigs it is a dietary necessity—avitaminosis B_7 results in "black tongue" in dogs and pellagra in man the latter disease being characterised by dermatitis, intestinal disturbances, nervous disorders and insanity.

Pantothenic Acid ($C_9H_{17}O_5N$) which is called the chick anti-dermatitis factor is widely distributed in foods of plants and animal origin such as liver, rice bran, molasses, wheat bran and yeast and avitaminosis is unlikely to occur. It can be synthesized by cattle and sheep but is essential in the diet of dogs, pigs, turkeys and probably the horse.

Other members of the vitamin B_2 complex are choline, associated with manganese deficiency as a cause of "perosis" or slipped tendon in chicks, inositol which is necessary for normal growth in chicks, for hair growth in mice and rats, and folic acid which promotes growth and prevents anæmia in chicks.

Vitamin C ($C_6H_8O_6$) or ascorbic acid is widely distributed in fresh fruits and in leafy and other vegetables. While it is absent from resting tissues it is present in germinating seeds, i.e., where metabolism is going on.

It is present in such animal products as muscles, glandular tissues and milk but in general they are poor sources.

Vitamin C readily undergoes reversible oxidation and functions in oxidation-reduction processes in the body cells. Hay making reduces the vitamin C potency of the original material and in milk pasteurisation and processing losses of 20 to 60 per cent. respectively may occur.

Slight shortages of ascorbic acid result in minor oral ailments; serious deficiencies cause scurvy. Certain species, e.g., rats, dogs and birds can synthesize this vitamin, farm animals with the exception of pigs seem unlikely to suffer from deficiencies and dietary need is otherwise restricted to guinea pigs, monkeys and man.

In addition to the more important vitamins mentioned a number of others have more recently been studied. Vitamin H or biotin $C_{10}H_{16}O_3N_2S$ occurs as a constituent of a protein molecule and its deficiency causes skin lesions in rats, chickens and probably man. Vitamin P, the constitution of which is unknown, occurs in fruit and vegetable juices. Avitaminosis P lowers capillary resistance and hæmorrhage develops. With vitamin C it assists in the prevention of scurvy. Vitamin F appears to be related to adermin, and is the name given to a number of essential and highly unsaturated fatty acids including linoleic and linolenic acids, which are necessary to prevent a deficiency disease of the skin.

Chemical Composition of Foods—

I. The Concentrated Foods—Compared with other groups of foods, the concentrates contain a high proportion of certain nutrients. They include foods of animal and vegetable origin and are conveniently subdivided into carbohydrate and protein rich foods.

Foods which are regarded as carbohydrate concentrates generally have protein equivalents of less than 10 but are correspondingly high in starch equivalent and include the cereal grains. These foods show wide variation in respect of oil ranging from 1·5 per cent. in barley to 4·8 per cent. in wheat. The protein content is less variable and is least in rice (8·3 per cent.) and greatest in wheat (12·1 per cent.). The crude fibre is also variable, because of the presence of husks in oats and barley and their absence from wheat and maize. In barley the husk forms about 10 per cent. of the grain and in oats about 25 per cent. The percentages of crude fibre in the grain range from 1·9 in wheat and rye to 10·3 in oats. The cereals are deficient and badly balanced in mineral matter but phosphate and potash are generally satisfactory. Lime and chlorine are invariably low and this combined with the deficiency of protein are serious factors in intensive milk production. These foods have a rachitogenic effect the result of their low lime content and of the presence of phytic acid which decreases the absorption of lime in these and other foods from the gut.

As mentioned earlier this group of foods is a particularly good source of vitamins B and E.

The carbohydrate-rich foods are used for fattening and to widen the nutritive ratio of diets rich in protein.

The protein concentrates consist of foods of animal origin such as dairy and slaughter-house by-products, e.g., whey, dried blood, meat meal, etc., and fish residues, and of foods of vegetable origin such as peas, beans, brewery and distillery by-products and cakes and meals from the oil-milling industry.

Protein-rich foods such as carcase residues are prepared in conformity with the Foot and Mouth (Boiling of Foodstuffs) Order, 1932, which with certain exceptions involves heating to at least 100° C. for a minimum period of 1 hour. The moisture and fat are removed by heating or the fat may be extracted by a solvent. The residues when dried are freed from the solvent and ground.

Dried blood contains about 80 per cent. protein but is low in mineral matter.

Meat meals vary in composition but may contain from 40–70 per cent. protein and, depending on the efficiency of extraction 2–17 per cent. fat. Meat and bone meal which contains ground bones in addition to ground meat meal contains about 50 per cent. protein and 10 per cent. each of lime and phosphoric acid. Sterilised steamed bone flour, prepared from bones from which fat and gelatin have been removed contains about 46 per cent. ime and 31 per cent. phosphoric acid. Fish meals vary in quality for feeding purposes. White fish meal made from heads, bones and adhering flesh of white fish, contains not more than 6 per ent. oil and 4 per cent. salt. Fish meal made from damaged oily fish contains 10–15 per cent. oil. The residual oil in the latter enders it unsuitable for animal feeding. These foods are all ich in high quality protein and certain of them are rich in lime and phosphoric acid.

The dairy by-products are residues from the manufacture of butter, cheese and other milk products or from the separation of ream. They may be fed in liquid form, containing about 90 per cent. water, or dried. Dried skimmed milk and separated milk are rich in highly digestible protein, and mineral matter nd contain most of the protein, lactose and ash of the original milk ; the dried buttermilk, which may contain salt, contains ather more protein and less lactose than dried separated milk the approximate composition of which is 30 per cent. protein, 47 per cent. lactose, 8 per cent. mineral matter. Dried whey contains about 70 per cent. lactose, 8 per cent. mineral matter 1.5 per cent. fat and only 12 per cent. protein since heese-making involves the removal of the greater part of the protein and some of the fat, from the milk.

The protein concentrates of vegetable origin include such ome-grown foods as peas and beans, by-product foods such as rewers' and distillers' grains, dried yeast, etc., and oil cakes. hey usually contain not more than 15 per cent. water. Peas nd beans are rich in protein (18–20 per cent.) and carbohydrate 52–44 per cent.) but contain only about 1 per cent. of ether xtract. Their ash content, 3 per cent. is low and resembles hat of the cereal grains since it is poor in lime and chloride but omparatively rich in phosphoric acid and potash. Dried rewers' and distillers' grains contain 12·5–19·5 per cent. rotein equivalent and have nutritive ratios of 1 : 3 or 1 : 4. hey are therefore approximately balanced for milk production. ne cereal milling offals are characterised by the presence of rger amounts of fibre, oil, protein and ash than either the flour r the original grain. In addition they are richer in vitamin B nd, since the germ is included with the offals they are a good ource of vitamin E.

The oil cakes and meals are prepared from the residues of oleaginous seeds containing 17–50 per cent. oil from which the oil has been extracted for soap and margarine making by hydraulic pressure, the expeller process or by solvent extraction. Hydraulic pressure residues contain 5–10 per cent. oil, residues from the expeller process contain 4–8 per cent. and the solvent-extracted meals contain only 1–2 per cent. oil. The latter process involves steam heating of the residues to remove the last traces of solvent. These cakes and meals are rich in protein but the amounts of oil vary with the extraction process and the crude fibre content varies with the degree of decortication.

In feeding practice fibrous foods must accompany protein concentrates to add bulk to the ration and to achieve the correct nutritive ratio.

II. **Bulky Foods—Roughages or Coarse Fodders**—These foods are characterised by a high fibre and low protein content and include hay, straw and chaff. The chemical composition of the standing crop for hay depends upon a number of factors not the least of which is the botanical composition of the sward. This factor is influenced by fertiliser and grazing practices, the relative proportions of inferior species such as Yorkshire fog and bent to rye-grass and timothy and by the amounts of clover and legumes present. The latter increases the amounts of protein and lime in the hay. The nutritive value of hay depends upon the stage of growth at which it is cut, the crude fibre increasing in amount and decreasing in digestibility as, with maturity, it becomes lignified. At the same time a transfer of nutrients such as protein from the vegetative parts to the seeds takes place. If hay be made later the seeds will be shed ; if present they may be resistant to digestion and valuable food material lost. If the crop be exposed to rain during hay-making considerable losses by leaching of mineral matter, protein and soluble carbohydrates take place. The chief mineral constituents affected are phosphoric acid, chloride and potash, the loss of lime being relatively small. The consequence is a reduction in palatability and feeding value.

Harvesting involves losses estimated at about 10 per cent. due to cellular respiration and the oxidation of carbohydrates to carbon dioxide and water for some time after cutting. Mechanical operations result in damage to the brittle dry leaf and cause losses estimated at from 5–10 per cent. while a similar loss in the stack may be attributed to fermentation by enzymes and bacterial action in addition to respiration losses where the hay has been imperfectly dried.

These losses do not affect the crude fibre and hence a high crude fibre content is further emphasised and decreases the digestibility of the hay. Similarly heating in the stack reduces digestibility.

The dry matter content of hay is of the order of 85 per cent., crude protein content varies from 7·5–13·5 per cent., and crude fibre from 33·5–19·3 per cent. for poor and good meadow hay respectively. The starch equivalent varies from 20–40 per cent. and the protein equivalent from 3–12 per cent. The mineral matter (5–8 per cent.) may be regarded as a good source of lime and phosphoric acid but the former may vary from 0·3–2·3 per cent. and the latter from 0·3–0·8 per cent. Hay made from leguminous swards is less variable in composition than meadow hay and average seeds hay contains 12 per cent. crude protein, 2·8 per cent. oil and 27 per cent. crude fibre with 1·5–2 per cent. lime.

The pro-vitamin A potency of grass is much reduced by haymaking, losses of carotene having been estimated at 50–60 per cent. depending upon conditions.

The growth of cereal crops to maturity to produce seed involves an almost complete transfer of nutrients from leaves and stem to the seed. Hence the straws are low in protein and high in fibre content and contain about 86 per cent. dry matter. Starch equivalents vary between 13 and 23 and protein equivalents between 0·1 and 0·7 the lowest values being for wheat straw. Since oats are cut before being completely ripe the straw is less lignified and has a higher nutritive value than other straws. Barley straw is of low feeding value ; its ash is poor in lime and phosphoric acid and contains much silica. The nutritive values of the straws can be improved by treatment with caustic soda and afterwards washing them free from alkali ; the process is known as " pulping."

THE SUCCULENT FOODS—

(*a*) **Roots and Green Foods**—This group of foods is characterised by the presence of 75–90 per cent. water and includes forage crops, e.g., lucerne, clovers, graminaceous crops, e.g., rye grasses and cereals, green crops, e.g., kale and rape, and roots and tubers, e.g., mangolds, swedes and potatoes.

Characteristics of these foods are the high percentage of carbohydrate (up to 20 per cent.) and the low content of protein, 2 per cent., and oil, 1 per cent. The roots have dry matter contents ranging from 8·5 per cent. in turnips to 10–14 per cent. in swedes ; potatoes have 22–24 per cent. dry matter. The dry matter of roots and tubers resembles that of the cereals since it is rich in carbohydrate and poor in protein, oil and ash. The type of carbohydrate differs however ; in potatoes it is largely starch and in roots a mixture of glucose and sucrose. In mangolds part of the carbohydrate present as sucrose undergoes inversion to glucose and fructose during the storage period without affecting the nutritive value of the roots. Although swedes have the highest nutritive value of all root crops they are exceeded in value by potatoes and barley since for ruminants sucrose has only 75 per cent. of the productive value of starch. In mangolds much of the nitrogen is in "amide" form and storage prior to feeding enables nitrate-nitrogen to be converted into amides.

Kales have a high mineral content particularly of lime, 1·6–2·6 per cent. chloride and potash and hence tend to make good the lack of lime in cereal grains and hay. In addition they contain satisfactory amounts of iron, magnesium and phosphoric acid. They are also useful sources of protein, vitamin C and carotene.

Sugar beet pulp contains about 85 per cent. water and may be fed in this condition or dried, the dried pulp being slightly inferior to oats in feeding value.

The comparative richness in protein of the green fodders makes them the natural supplement for carbohydrate-rich foods.

Grassland herbage—Grassland herbage contains about 20 per cent. dry matter the amount and composition of which varies with the stage of maturity. The chemical composition of grassland is largely influenced by management which results in changes in botanical composition and hence in nutritive value. Composition and digestibility may also be affected by climate, e.g., low temperatures decrease the growth rate and this is accompanied by increased lignification and decreased digestibility and feeding value even though the grasses are still in the leafy stage.

Marked increases in the percentages of crude fibre occur with increasing maturity. In young plants cellulose forms a large proportion of the crude fibre ; at this stage the cellulose cell walls are easily disrupted and their contents subjected to bacterial fermentation so that 75–80 per cent. of the crude fibre is digestible. As the plant matures the ratio of stem to leaf increases, cell walls become lignified and resistant with the result that the crude fibre is less digestible. In addition the mineral and vitamin contents of the grasses decrease with advanced stage of growth.

Controlled, intensive grazing results in grass of the character of a protein concentrate with amounts of protein, on a dry matter basis approaching or equalling that of linseed cake and being of high biological value :

TABLE 95

Pasture Herbage	Crude Protein per cent.	Crude Protein in Dry Matter per cent.
Close grazed, 3-weekly intervals	4·5	22·5
Close grazed, 4-weekly intervals	3·5	17·5

The grass is also rich in ash (9 per cent. on dry matter), particularly in lime, phosphoric acid and potash, and in carotene.

Dried Grass—Grass produced under conditions of good management and cut and dried at the correct stage has the character of a protein concentrate and is also rich in minerals and carotene. Losses of carotene on drying may, according to Fagan and Ashton, vary from 10–60 per cent. with 33 per cent. as an average, further oxidation losses occurring during storage. Because of the variability in composition dried grass is classified thus :

Grade	Crude Protein in Dry Matter per cent.
1	over 17
2	14 – 17
3	12 – 14
Super hay	8 – 12

Silage—In composition and digestibility well made silage does not differ much from that of the fresh crop. The crude protein, fibre and ash of the silage are about 16 per cent. higher than in the original crop and the ether extract, due to the inclusion of organic acids with this fraction, is considerably higher. Well preserved silage has a pH value of 4·0 4·5, overheated samples have very similar pH values, while pH values of underheated samples are usually more than 5. The crude protein content of well preserved silage is indicative of the stage at which the fresh material was cut, but overheated samples although highly palatable are regarded as poor irrespective of analysis since the extent to which the digestibility of the protein has been impaired can not be easily gauged.

In the evaluation of silage the dry matter figure is of chief importance since it determines the amount of nutrients which the sample will supply to the ration as a whole. While pH may be useful for classifying silage it is not absolutely indicative of suitable fermentation.

Silage colour varies with the degree of heating and oxidation. Low temperature silage is olive green, well preserved silage light brown and high temperature silage is dark brown. The change of colour is the result of the formation of phæophytin, a magnesium-free pigment, from the chlorophyll.

There is appreciable conservation of the carotene in well preserved silage, the amount present depending on the amount of heating and oxidation which takes place, but overheated silage is a poor source of carotene. In respect of carotene silage compares favourably with fresh grass and is much superior to hay thus :

TABLE 96

Carotene Content of Grass and Grass Products

	Carotene (mg./Kg. of Dry Matter)
Fresh grass	300–600
Dried grass	250–500
Silage	250–500
Meadow Hay	10–40

NUTRITIVE VALUES OF FOODS—

Digestibility—The digestibility of foods is determined by experiments with cattle or sheep during which the amount of food fed and fæces voided per day and per experimental period are noted. Representative samples of foods and fæces are taken daily for analysis and allowance is made for unconsumed food. Analysis of foods and fæces gives information on the total dry matter consumed and voided and of the relative extent to which other constituents e.g., protein have been digested. Results, expressed as percentages of the amount of total dry matter or nutrient consumed are known as digestibility coefficients (the assumption thereby made is that fæcal residues are indigestible, in fact, for a number of reasons this is not strictly true). The percentages of digestible nutrients are then calculated using the digestibility coefficients from the total percentages of nutrients given by analysis.

The digestibility of crude protein can be estimated by the digestion of the food protein "in vitro" using a solution of pepsin in dilute hydrochloric acid. Results are, however of limited use and vary with the fineness with which the food is ground.

The digestibility of foods also varies "in vivo" and in general is mostly affected by the crude fibre content. A high percentage of crude fibre is associated with the maturity of grassland products ; its resistance to the digestive juices protects the constituents of the cells from digestion and thus decreases the digestibility of the food as a whole. There appear to be but slight differences in the relative capabilities of young and old animals to digest foods, and while gentle exercise stimulates digestion hard work may impair it.

The effect of grinding on the digestibility of coarse foods is probably negligible but the process reduces the mechanical operations of the animal in mastication and consequently enhances their feeding value. In the case of foods which tend to form a doughy mass in the stomach the presence of a proportion of fibrous food such as bran helps to open up the mass to the action of the digestive juices. Peas, beans, maize, linseed, barley, oats and wheat have a tendency to pass unaltered through the alimentary tract unless crushing or grinding has taken place.

The digestibility of foods also varies with the manner of preparation, for example, the protein of overheated silage is less readily digested than that of a well made sample and the digestibility of hay, overheated in the stack, is also impaired. Cooking may improve the palatability of certain foods and increase the digestibility of carbohydrates but it lowers the digestibility of protein.

Ruminants, by virtue of the microflora of the rumen, have a greater capacity than non-ruminants to digest fibrous foods. The comparative inefficiency of the horse in making use of crude fibre is probably due to the reduced size of the digestive tract and to the fact that fibre digestion takes place largely in the cæcum after gastric and small intestinal digestion has taken place.

ENERGY VALUES—

The purpose of food is firstly to keep the animal alive and secondly to enable it to produce work, growth, fat, milk, eggs or the young of its species. That part of its diet which is used to keep it alive is called a maintenance food ; that which is given in addition to the maintenance allowance is called a production food.

The amount of energy which a food contains can be determined by measuring the heat emitted when it is completely oxidised in a bomb calorimeter. This value is usually expressed in terms of calories per unit mass of food.

One calorie is the amount of heat required to raise the temperature of 1 gram of water through 1°C and 1 kilocalorie (1 Cal.) represents the amount of heat required to raise one kilogramme (1000 g.) of water through 1°C. The latter unit is used almost exclusively in animal nutrition but in the United States of America the Therm (1000 Cal. or Kilo-calories) is used.

The energy liberated by a food on complete oxidation is variously known as the Gross Energy, Gross Chemical Energy, Energy of Combustion, Chemical Energy or Total Energy.

The amount of this energy which the animal can utilise depends upon the extent to which digestion takes place. Hence the energy remaining after deducting the energy value of the undigested fæcal residues is known as the Digestible Energy.

In addition to losses in the fæces a considerable amount of energy is lost in the form of methane produced by bacterial fermentations in the rumen and also as unoxidised metabolic residues, e.g., ures, uric and hippuric acids in the urine. When the total energy value of the excrement, solid, liquid and gaseous, is deducted from the Gross Energy the amount of energy which is available to the animal is obtained ; it is known as the Metabolisable Energy. Thus :—

1. Gross Energy—Energy value of fæcal residues = Digestible Energy.
2. Digestible Energy—Urinary and gaseous energy = Metabolisable Energy.
3. Gross Energy—Total energy of excrement = Metabolisable Energy.

The energy required to maintain the animal body in a resting condition and to supply heat lost by respiration, by the work of the involuntary muscles, and by the temperature difference between the animal and its surroundings, i.e., by conduction, convection and radiation is known as the metabolisable energy. This energy may be regarded as being completely useful to the animal.

The following table shows the heat liberated (gross energy) on complete oxidation by 1 gram of the pure digestible nutrient :

TABLE 97

GROSS ENERGY OF FOODS

Pure Digestible Nutrient	Heat liberated Cal/g.
Lard	9·48
Butterfat	9·21
Seed fat	9·33
Casein	5·86
Albumin	5·80
Starch	4·23
Cellulose	4·10
Sucrose	3·96
Lactose	3·60
Asparagine	3·30
Urea	2·40

From these figures the gross energy or heat of combustion of fats, proteins and carbohydrates may be taken as 9·3, 5·8 and 4·1 Cal/g. respectively. After allowance has been made for the energy value of excrement these groups of nutrients have the following heat value or metabolisable energy value to the animal :

Pure Digestible Nutrient	Cal/g.	Cal/lb.
Oil and Fat	8·8	4000
Protein	4·7	2133
Carbohydrate	3·7	1707

Taking the heat value of carbohydrate (starch) as 1, the values of protein and fat become respectively 1·25 and 2·3. Consequently the metabolisable energy of a food may be expressed in terms of heat (Calories or Therms) or of starch. Thus for linseed cake :

Digestible Nutrient	per cent.	Factor	Starch Value	Heat Value in Cals.	
Protein Equiv.	24·5	x 1·25 =	30·63	24·5x2133 =	52,258
Oil	9·0	x 2·30 =	20·70	9·1x4000 =	36,000
Carbohydrate and Fibre.	30·0	x 1·00 =	30·00	30·0x1707 =	51,210
			81·33		139,468

The figure obtained in the first column represents the maintenance starch equivalent of the food ; it is in fact an expression of the energy made available to an animal, the metabolisable energy, from a food in terms of starch.

Since animals rarely receive the minimum energy (food) allowance necessary for maintenance, surplus or supplementary energy will be available for productive purposes such as growth and the formation of fat, wool, milk, etc. This additional energy has a lower value to the animal than that given for maintenance since part of it is expended in the processes of digestion and conversion to assimilable nutrients. The heat so formed is surplus to the body's requirements and so is valueless to the animal. Moreover it has been shown that the utilisation of this supplementary energy causes an increase in the rate of metabolism as shown by an increased production of carbon dioxide and heat. Of the food constituents proteins in particular exert a stimulating effect on *the energy exchanges of the body*. The increased rate of metabolism as a result of the consumption of large amounts of protein is usually referred to as Specific Dynamic Action.

The real production value of a food is therefore the metabolisable energy less the thermal energy produced during its conversion to assimilable form ; it is known as the Net Energy.

Since some foods are more easily digested and converted than others the thermal energy produced in the process is variable and consequently their net energy values will differ. The discrepancy between metabolisable and net energy values is greatest with fibrous foods, in fact the horse expends more energy on the digestion of wheat straw than is made available from that food. Such a material therefore possesses a negative net energy value. Conversely milk, which is almost completely digestible, has a high metabolisable energy value and, since it is easily digested and converted to assimilable nutrients, its net energy is also high.

Net energy values therefore vary with the food and with the animal consuming it. They also vary with the purpose for which the food is provided, i.e., for maintenance, growth or milk or fat production. It has been shown that the conversion of metabolisable energy to milk is 69·3 per cent. efficient while the efficiency of its conversion for fattening is only 57·5 per cent. The net energy values also vary with the plane of nutrition, animals on low and sub-maintenance standards of feeding making more efficient use of this food. Furthermore the net energy value of a food also depends on the nature of other foods fed in conjunction with it.

Net energy values as determined by Armsby in America and expressed in terms of starch possibly underestimate the value to the animal of the supplementary food, particularly fibrous foods, by the assumption that it makes no contribution to maintenance Some part of it may be utilised to maintain the constancy of body temperature and would therefore serve a useful purpose.

Fat-producing capacity of Foods—Starch Values—The effect of feeding known weights of pure digestible nutrients in addition to the basal or maintenance rations of store bullocks was determined by Kellner, a German nutritionist. The resultant gains in body weight were expressed in terms of fat and from the body increase the fat-producing power of the pure nutrients of which foods are composed was found. It was discovered in addition that the fat producing capacity of oils and fats varied with their source and that the digestible fibre had the same value as starch. The fat-forming capacities of the pure digestible nutrients are :—

Pure Digestible Nutrient	Amount of Body fat formed for one pound nutrient fed lb.
Carbohydrate	0·248
Protein	0·235
Fat from coarse fodders ...	0·474
Fat from cereals	0·525
Fat from oil seeds ...	0·598

Using these values it is possible to calculate the fat forming power of foods thus :—

Linseed Cake

Digestible Nutrient	Per cent.		Factor		Fat formed lb.
Protein Equivalent ...	24·5	×	0·235	=	5·76
Oil	9·0	×	0·598	=	5·38
Carbohydrate Fibre	30·0	×	0·248	=	7·44
					18·58

Therefore 100 lb. linseed cake have a theoretical fat-forming value of 18·58 lb.

Submission of the above theoretical factors to practical test showed discrepancies with the experimentally determined values for fat obtained. Moreover it was seen that while agreement was close with concentrated foods discrepancies were most marked with roughages due to the fact that energy was expended in dealing with the indigestible portion of the food.

A relationship was established between the fibre content of a food and its actual fat-forming capacity, i.e., to the ability of the individual nutrients of a food to function as if they were pure. This relationship is expressed as a percentage of efficiency or availability and is known as " V "—the Value Number. For linseed cake this V number is 97, hence, in the example above the actual fat-producing value of linseed cake is

$$\frac{18\cdot58 \text{ x } 97}{100} = 17\cdot74$$

The numerical value of V is influenced by the nature and quality of the food and by the percentage of crude fibre.

Starch Equivalent—As an alternative to expressing the fat producing power of the digestible nutrients in 100 lb. of a food in terms of fat Kellner suggested that soluble carbohydrate, i.e., starch be used as the unit. Thus the number of pounds of starch necessary to produce the same amount of fat as 100 lb. of a particular food was called the Starch Equivalent. Hence the starch equivalents of Kellner's theoretical values for the fat producing capacities of pure digestible nutrients could be calculated :

Pure Digestible Nutrient	Fat formed for each lb. nutrient lb.	Fat formed relative to Starch	Starch Equivalent
Carbohydrate ...	0·248	$\frac{0\cdot248}{0\cdot248}$	1·00
Protein	0·235	$\frac{0\cdot235}{0\cdot248}$	0·95
Fat from coarse fodders	0·474	$\frac{0\cdot474}{0\cdot248}$	1·91
Fat from cereals ...	0·525	$\frac{0\cdot525}{0\cdot248}$	2·12
Fat from oil seeds ...	0·598	$\frac{0\cdot598}{0\cdot248}$	2·41

Using the above factors it is therefore possible to calculate the Starch Equivalent of a food. Once again, to take linseed cake as an example :

Digestible Nutrient	per cent.		Factor	Theoretical S.E.
Protein Equivalent	24·5	×	0·95	23·27
Oil	9·0	×	2·41	21·69
Carbohydrate and Fibre.	30·0	×	1·00	30·00
				74·96

Since V = 97

Actual Starch Equivalent will be $\frac{74\cdot96\times97}{100}=72\cdot7$

This is known as the Production Starch Equivalent.

For all practical purposes starch equivalent and net energy may be regarded as similar values. Therefore they may be converted the one into the other since 1 lb. starch yields 1,071 Cal. of net energy.

While the V numbers for concentrated foods of high digestibility were in accord with results obtained in practice a different procedure was recommended by Kellner for coarse and green fodders for which V is numerically small, thus :—

Coarse Fodder	Crude fibre per cent.	lb. S.E. to be deducted for each 1 per cent. Crude Fibre
Hay and Straw (long)	—	0·58
Hay and Straw (chaffed)	—	0·29
Green fodders	More than 16	0·58
	14–16	0·53
	12–14	0·48
	10–12	0·43
	8–10	0·38
	6– 8	0·34
	4– 6	0·29

While starch equivalents are useful as a basis for the evaluation of foods their limitations must be remembered. For example they make no distinction between that part of an animal's food which supplies energy, viz., carbohydrates and fats and that which is required for body building purposes—proteins. Secondly because of the laborious nature of the experimental work involved many of the net energy values have been computed and not determined. Thirdly, results obtained by Kellner from feeding animals in store condition and by Armsby from feeding animals on sub-maintenance levels have been applied to milk production, work and growth, and to all classes of livestock. Moreover no account was taken of the relative ability of different species to utilise to a greater or less extent particular nutrients, e.g., poultry, pigs and horses are unable to digest crude fibre as efficiently as ruminants. A further limitation is the variability in composition of foods due to seasonal, soil, manurial and other factors and the presumption that adequate vitamins and minerals will be present in adequate amounts.

Total Digestible Nutrients—Because of the variable efficiency of conversion of metabolizable energy in milk production or fattening, i.e., because the net energy per Therm of metabolizable energy is variable, net energy values as a basis of feeding are no longer used in the United States of America. There, requirements are stated in terms of metabolisable energy and/or total digestible nutrients (T.D.N.) which is calculated thus :

$$\text{T.D.N.} = \%\ \text{Dig. Carbohydrate} + \%\ \text{Dig. Fibre} + (\%\ \text{Dig. Oil} \times 2{\cdot}25) + \%\ \text{Dig. Crude Protein.}$$

The metabolisable energy of a ration may be calculated on the assumption that 1 lb. total digestible nutrients of a good mixed ration has a metabolisable energy value of 1,616 Calories.

Scandinavian Food Unit System—In this system requirements are stated in units (1 kg.) of barley meal, the food requisite to the production of 1 gallon of average quality milk. Recognition of the varying efficiencies of foods for fat or milk production is made together with allowances for variation in the quality of the foods above or below a medium standard. No attention however is paid to the vitamin or mineral status of the diet, nor is adequate attention paid to the protein quality.

Nutritive Ratio—Whatever system be used to express the energy value of a food it must be remembered that all constituents, fats, proteins and carbohydrates contribute towards the total. It has been shown that fats and carbohydrates may be regarded as energy-yielding nutrients and to this extent they are interchangeable but the animal's essential need for protein can only be supplied from the food protein. Some foods are rich in carbohydrate and/or oil and have low percentages of protein while others are rich in protein with a relatively smaller proportion of carbohydrate. The balance of a food in respect of these constituents is expressed by the nutritive or albuminoid ratio which is :

$$\text{Nutritive Ratio} = \frac{\text{Digestible non-protein constituents}}{\text{Dig. Protein} + \text{Other Dig. Nitr. Constituents}}$$

$$= \frac{\text{Energy}}{\text{Effective Protein}}$$

$$= \frac{\text{Percentage Dig. Carbohydrate} + \text{Percentage Dig. Fibre} + (\text{Percentage Dig. Oil} \times 2\cdot3)}{\text{Percentage Protein Equivalent}}$$

(Digestible Oil is multiplied by 2·3 because 1 lb. yields 2·3 times as much heat energy as an equal weight of starch.)

Ratios of 4 : 1 are regarded as narrow, i.e., they are high in protein, ratios of 8 : 1 are wide indicating foods rich in fats and carbohydrates. Well balanced foods have ratios of about 6 : 1. The feeding of young growing stock necessitates adequate supplies of protein hence a narrow ratio is suitable ; the adult animal, which utilises energy for fat formation and may make comparatively little growth, will require a wide ratio.

For convenience, since the data can be obtained without calculation from tables giving data on the composition of foods, the ratio of starch equivalent to protein equivalent is sometimes used. It is not the same as the nutritive ratio for it is calculated thus :

$$\frac{\text{S.E.}}{\text{P.E.}} = \frac{\%\,\text{Dig.Carb.} + \%\text{Dig. Fib.} + (\%\text{Dig. Oil} \times 2\cdot3) + (\%\text{P.E.} \times 0\cdot94)}{\%\,\text{P.E.}}$$

Rationing—Rationing involves consideration of the animal's maintenance and production requirements in relation to the economic utilisation of available food. The maintenance requirements include supplies of energy and protein for the vital metabolic processes, while the weight of the animal remains constant. Productive food, which is supplied in addition to that required for maintenance is utilised for growth by the young animal, for work, or for the production of a body product, e.g., wool, milk, eggs, fat or a fœtus.

In addition to the correct balance of foods and to their supply in adequate amounts, vitamins and minerals must also be present in a complete diet. It was indicated earlier that under conditions of good husbandry shortages of these accessory foods should not arise.

Since the food fed must also satisfy the animal's appetite the " bulk " of the ration must be considered. It must not be so low that the animal feels hungry nor so high that the restricted capacity of its digestive tract is strained. For cattle, horses and sheep a fairly satisfactory practice is the provision of food, expressed in terms of dry matter, to the extent of 2·5–3 per cent. of body weight. For larger animals, and for high yielding cows the higher figure may require to be exceeded.

Foods should be palatable, those rich in sugar, oil and protein and the succulent foods generally, are preferable in this respect to dry or coarse foods. Palatability may also be reduced by physical or chemical properties of the foods, e.g., coarse herbage or leaves covered with fine hairs, and glucosides. It may be increased by the addition of condiments or of molasses.

Generally a ration should be mildly laxative to assist the elimination of waste products. Succulent foods, due partly to their high moisture content and partly to their "amide" content, and foods rich in oil, are laxative while fibrous foods are costive. Thus when scouring or costiveness are acute a food producing the opposite effect would be fed.

It is also necessary to consider the effect of food fat on body fat and milk fat. The former was indicated under the discussion on fats. Similarly food fat may influence the hardness of butterfat, the unsaturated fats and oils producing soft fats; carbohydrates tend to produce hard fats. Certain foods, e.g., fish meal; certain weeds, e.g., garlic, water parsnip, etc.; and certain crops, e.g., kale, lucerne, etc., may produce taints in milk. Care must be taken therefore with foods, over which control may be exercised, to feed these after milking or so long before that the causative substances have been eliminated from the body by the time of milking. Foods such as kale or silage could be fed out of doors to avoid milk acquiring taints by absorption from the air.

FEEDING

A ration is generally considered as consisting of (*a*) the Maintenance portion; (*b*) the Production portion.

The amount of energy to be supplied in each of these parts is expressed as Starch Equivalent and the amount of protein as Protein Equivalent.

Maintenance Ration—

Table 98 sets out the maintenance starch equivalent and protein equivalent requirements of animals of different live weights.

TABLE 98

Live Weight	S.E. (Starch Equivalent) per day	P.E. (Protein Equivalent) per day
lb.	lb.	lb.
100	1·07	0·11
200	1·79	0·18
300	2·43	0·24
400	3·01	0·30
500	3·57	0·36
600	4·08	0·41
800	5·07	0·51
1000	6·00	0·60
1100	6·44	0·65
1200	6·87	0·69
1400	7·72	0·77
1600	8·53	0·85

It will be seen that the starch equivalent–protein equivalent ratio in the maintenance requirements is approximately 10: 1.

In stating the requirements of sheep for maintenance a small addition should be made to the protein equivalent to allow for growth of wool. This is shown in Table 99.

TABLE 99
Maintenance Requirements of Sheep.

Live Weight	P.E. per day	S.E. per day
lb.	lb.	lb.
60	0·08	0·73
80	0·10	0·90
100	0·12	1·07
140	0·16	1·38
160	0·17	1·52
200	0·20	1·79

The maintenance requirements of horses can be conveniently expressed as an amount of dry matter per day to be fed in the form of good quality roughage, usually hay. If hay is assumed to contain approximately 85 per cent. dry matter the amount needed for the daily maintenance of horses of different weights can readily be calculated as in the table below.

TABLE 100
Maintenance requirements of Horses shown as lb. of Dry Matter and lb. of Hay per day.

Weight of Horse.	Dry Matter per day.	Hay per day.
cwt.	lb.	lb.
6	9	10½
10	13	15¼
12	14¾	17½
14	16¼	19
15	17	20
16	17¾	21
18	19¼	22½

Production Ration—In addition to the energy (starch equivalent) and protein (protein equivalent) required for maintenance animals have additional energy and protein requirements for production. Production may take the form of growth, work, milk, development of fœtus, fat. The amount of starch equivalent and protein equivalent needed for production is called the production requirement and the production ration is that amount of food which satisfies these requirements.

Cows.

MILK PRODUCTION—The amount of energy and protein to be supplied will increase as the percentage butter fat in the milk increases.

TABLE 101

Butter Fat Percentage	S.E. lb. per gallon	P.E. lb. per gallon
3·5–3·8	2·5	0·55
4·0	2·6	0·58
4·25	2·7	0·61
4·50	2·8	0·63
4·75	2·9	0·66
5·25	3·1	0·72

Ewes

Milk Production—There is little authentic knowledge regarding the milk yields of ewes of different breeds.

An average yield of three gallons per week is generally assumed.

As ewes' milk is richer than cows' milk, containing nearly 7½ per cent. fat and 6½ per cent. protein it is necessary to supply more S.E. and P.E. per gallon than to cows in milk.

Per gallon of milk produced by ewes supply 4 lb. of S.E. and 1 lb. of P.E.

Fattening Cattle—For each 1 lb. of live weight gain per day supply :—

In early fattening stage	...	2¼–2½ lb. S.E.
In middle fattening stage	...	3 lb. S.E.
In final fattening stage	...	3¾–4 lb. S.E.

The protein requirements of a steer being fattened are best expressed as a desirable S.E. and P.E. ratio *in the whole ration.* This will be 7 : 1 or 8 : 1. The actual protein equivalent of the whole ration will thus vary from approximately 1·3 lb. per day to 1·6 lb. per day with an average of 1·5 lb. per day over the whole period. These protein standards are known to be generous.

Fattening Sheep—Sheep being fattened have much the same requirements as steers although it must be remembered that in many cases sheep will be growing and fattening at the same time.

Table 102
Production Requirements.
Growing, Fattening Sheep.

Live Weight lb.	S.E. lb. per 1 lb. Live Weight Gain
60	1½
70	1½
80	1½
90	1¾
100	2
120	2½
140	3
160	3¾

Briefly—

In early stages ...	1½–1¾ lb. S.E. for 1 lb. L.W.G.
A little later ...	2 lb. S.E. for 1 lb. L.W.G.
Final stages ...	3 lb. S.E. for 1 lb. L.W.G.
If rapid fattening is aimed at ...	4 lb. S.E. for 1 lb. L.W.G.

The protein requirements may, as with cattle, be expressed as a desirable ratio between the S.E. and P.E. in the whole ration.

At 3 months	S.E. : P.E.	5 : 1
At 6 months	S.E. : P.E.	6 : 1
At 9 months	S.E. : P.E.	7 : 1
At 1 year	S.E. : P.E.	8 : 1

Steaming up of Dairy Cows—The expression " steaming up " refers to the additional food fed to an in calf heifer or cow during the six to eight weeks period before parturition. Commonly the cow will start this period by receiving 3–4 lb. of meal balanced for milk production or its equivalent in some other food. The quantity will be steadily increased until she may be receiving about three-quarters of the production ration she will probably need after calving. The amounts fed to an individual cow for this purpose will vary according to her condition and anticipated yield.

Requirements of Pigs—The rate of growth of pigs is so rapid that it is difficult to divide the ration into maintenance and production parts. The starch equivalent of good pig rations should be within the range 67–70 per cent., this together with the fact that the appetite of pigs of different live weights is reasonably well established enables their requirements to be stated in lb. of meal per day with an S.E. of 67–70 per cent.

The protein requirements may be stated either as a percentage P.E. in the ration or as the S.E. : P.E. ratio most suited to each stage of growth and fattening.

TABLE 103

Live Weight	lb. of meal per day	P.E. per cent.	S.E. P.E. Ratio
30 lb.	1·6	14	4–5 : 1
50 lb.	2·5	13	
60 lb.	3·0	12	5–6 : 1
80 lb.	3·5	12	
100 lb.	4·0	11	6–7 : 1
120 lb.	4·5	11	
140 lb.	5·0	10	
160 lb.	5·5	10	7–8 : 1
180 lb.	6·0	9	
200 lb	6·0	9	

Crowther in 1936 suggested that young pigs required a higher protein intake as indicated in Table 104.

TABLE 104

Requirements of Pigs (C. Crowther).

Live Weight lb.	Meal per day lb.	Per cent. Protein in Food
30	1·6	20·0
40	2·1	17·8
60	3·0	15·3
80	4·0	13·6
100	4·6	13·4
120	5·3	12·5
140	5·9	11·7
160	6·45	11·2
180	6·7	11·0
200	7·0	10·7

Feeding Requirements of Breeding Stock—In-pig sows and gilts may be fed on the general rule of 1 lb. meal of S.E. 67–70 per 100 lb. body weight plus any addition required to get her into a good condition after weaning and to allow for growth of pigs in utero.

A 300–350 lb. sow requires during pregnancy about 6–7 lb. of meal or meal equivalent per day with a S.E. of 67–70 and a S.E. : P.E. ratio of 4½–5 to 1.

Suckling sows and gilts require a ration with a narrow ratio of 4–5 to 1 with a S.E. in the meal of 67–70 per cent. A general guide as to quantity is 1 lb. meal or meal equivalent per day for each pigling plus an additional 2 lb. Thus a sow with eight piglings would be offered 10 lb. meal or meal equivalent.

Stock boars need feeding at the rate of about 1 lb. meal or meal equivalent per day per 100 lb. L.W. plus additional amounts at times. The ratio of the whole ration should be 4½–5 : 1 and the scale of meal feed such as to maintain the boar in a lean condition.

Pigs being fed for pork production may receive food on the scale shown in Table 105 (V. C. Fishwick).

TABLE 105

	lb. L.W.	lb. meal/day.
Small Porkers	75–80	4 (approx.)
Small Porkers	100	5 ,,
Porkets	80	4 ,,
Porkets	100–110	5 lb. ,,
Large Pork	120	5–5½ ,,
Large Pork	150	6–6½ ,,

The S.E./P.E. ratio may be as for bacon pigs of same weights until the final three weeks or so when it may be widened to 7–8 : 1.

Growth of Cattle—The following table applies to heifers and steers where the heifers are the dairy herd replacements and the steers are not to be fattened until mature. In other words the steers and heifers are to grow but not to fatten.

Where steers are required to fatten at an earlier age then a more generous allowance should be made to allow for a gain in excess of 1 lb. per day.

Live Weight. cwt.	S.E. per 1 lb. L.W.G. lb.
3	1½
5	1¾
6½	2
8	2¼

The protein equivalent requirements of growing cattle may be expressed as a suitable S.E. : P.E. ratio at various weights.

Up to 200 lb. Live Weight ...	S.E. : P.E.	5 : 1
At about 350 lb. Live Weight	S.E. : P.E.	6 : 1
At about 600 lb. Live Weight	S.E. : P.E.	7 : 1
At about 700 lb. Live Weight	S.E. : P.E.	8 : 1

Production of Work by Horses—Requirements are related to type and speed of work. Work is usually classified as light, medium and heavy. Light work carried out at speed rating as medium and so on. Requirements may be shown in term of S.E. and P.E. but in practice they are more conveniently expressed as pounds of oats.

TABLE 106
Work production of Horses.

	lb. D.M. additional to M.R. per day.	lb. of Oats per day.
Light work ...	6	7
Medium work ...	9½	11
Heavy work ...	14½	16½

Part of the oat ration may be replaced by other foods as in the following table of oat replacements.

		lb.
10 lb. Oats =	Maize	7·7
	Barley	8·4
	Beans	9·0
	Dried Brewers' Grains	12·3
	Swedes	90
	Mangolds	90
	Bran	13·2

The water requirements of stock must not be overlooked. Supplies are too often totally inadequate and frequently far from clean and pure.

A part of the animals need will be supplied in the feed and the greater the amount of succulent food eaten the lesser the need for water to be fed direct. The ideal is for all stock to have access at all times to a constant supply of clean water. As a guide the following daily quantities are suggested.

Horses	8–10 gallons.
Fattening cattle	6–7 gallons in winter. 7–8 gallons in summer.
Pigs (fatteners) ...	3 lb. per 1 lb. dry meal when young reducing to 1½ lb. for 1 lb. dry meal in later stages.
In-pig Sows ...	At least 1 gallon.
Suckling Sows ...	4–5 gallons.
Cows in milk ...	7–10 gallons according to size of animal and other factors plus 1½–2 gallons per gallon of milk produced.
Young cattle ...	Growing actively. Requirements are best met by an *ad lib* water supply.
Sheep	Will usually obtain all they require without having it carried to them.

The dry matter of a ration should be within the appetite of the animal. An excessively bulky ration is most unsuitable. On the other hand an over-concentrated ration for animals such as ruminants in particular results in the animal feeling unsatisfied. Furthermore such a ration prevents the correct functioning of the bowels.

Whilst the dry matter capacity of animals is not precisely known the following may be taken as reasonably correct :

Cattle	2½ per cent. of body weight. This may increase to a little over 3 per cent. in high yielding cows.
Horses	On light work its appetite is about 2 per cent. of live weight. On heavy work its ration should contain approximately 2¾ lb. dry matter per 100 lb. body weight.

Sheep	A general figure of 2½ per cent. of live weight is used. Records of food consumption of some sheep have shown larger amounts than this consumed up to 3 per cent.
Pigs	The capacity or appetite of the pig is clearly shown in Table 105 where its requirements per day are shown as lb. of meal of about 87–90 per cent. dry matter.

FEEDING STUFFS

Many and varied foodstuffs are in use. The following notes are a brief guide to a number of foods in common use.

Cereals. Barley—Barley is a safe food for all classes of stock. It must be remembered that all cereals have a wide S.E. P.E. ratio and require to be suitably balanced with higher protein foods if used in production rations for milk and growth. For cattle and sheep barley is best rolled or ground rather coarsely. For pigs it is usually fed as a meal. If used in place of oats for horses barley should not replace more than half the oats. It is a most satisfactory food for pigs, producing a firm fat.

Wheat—Wheat has about the same energy value as barley but a rather higher protein equivalent. Wheat may be fed to all classes of stock. This cereal should not be ground too fine otherwise the meal becomes pasty. Wheat should not be fed fresh to horses nor in large amounts. May form 25–30 per cent. of the meal ration of cattle and sheep. A rather larger proportion than this can be fed to pigs in the later stages of fattening. It is a standard food for poultry. Wheat should be ground for all stock.

Oats—Oats are very palatable and probably the safest cereal to feed to any class of stock. Due to the husk they are rather high in fibre and should not be fed in excessive amounts to pigs and poultry. Whilst not suitable for young pigs they may form one-third to one-half of the ration of older fattening pigs and breeding stock. Oats have a particular value for young cattle, foals and lambs. Sussex ground oats are widely used for poultry. Oats are often the sole cereal fed to horses. Freshly harvested oats are not a suitable feed; this is so particularly for horses. In feeding to cattle and sheep oats are usually crushed and for pigs finely ground. They may be fed whole to horses.

Maize—Yellow maize has an advantage over white in that it contains appreciable quantities of carotene the precursor of Vitamin A. The proteins of maize are of poor biological value and the fat of animals fed on excessive amounts will be rather soft and yellow. Maize may replace part of the oats in the ration of horses 0.77 lb. of maize being able to replace 1 lb. of oats. This cereal is widely used in pig and poultry feeding and can also be used in the rations of cattle and sheep.

RYE—This cereal is rather less palatable than the others but in food value is much the same as barley and wheat. Rye may contain a fungus, ergot, which is poisonous and may cause abortion. If fed fresh may cause digestive troubles. Horses should not be given large quantities. It may be used more freely for cattle and sheep, even replacing entirely the other cereals in a ration. In the rations of pigs and poultry rye may replace the barley or wheat.

By-products of Cereals. WHEAT—Prior to the war these types of wheat feed were available—weatings, superfine weatings and bran.

Weatings contained not more than 5·75 per cent. fibre, superfine weatings nor more than 4·5 per cent. The starch equivalent of these two foods lay between 64–68 per cent. That of bran about 42 per cent. At the present time (1951) only weatings and bran are available.

Bran is high in crude fibre (9–10 per cent.), is palatable, rather bulky and, if given as a wet mash, rather laxative. It is rich in P_2O_5. It is more suited to ruminants than pigs or poultry, and on account of its laxative properties is fed to horses. It is balanced for milk production. Weatings have a higher energy value, are lower in crude fibre and more digestible. Weatings are a very safe food for pigs of all ages and may form a substantial part of the ration. Weatings may be fed to all classes of stock.

FLAKED MAIZE—A very digestible food with a wide S.E./P.E. ratio of 9 : 1. It may be fed to all classes of stock. Its physical state will help to lighten an otherwise heavy meal mixture.

Brewers' Grains and Distillers' Grains—These are sold both in wet and dry state. Ellis gives the following analyses :

	S.E.	P.E.
Fresh Brewers' Grains ...	18·4	5·3
Fresh Distillers' Grains ...	16·2	6·0
Dried Brewers' Grains ...	48·3	12·5
Dried Distillers' Grains ...	57·2	19·1

The wet or fresh forms are very palatable and being approximately balanced for milk production are frequently fed to milking cattle. About 12–15 lb. are sufficient to provide the energy and protein required for one gallon of milk. Other types of cattle can also be fed the wet grains. Excessive feeding of wet grains to milking cows may stimulate the production of large yields of poor quality milk.

Dried Brewers' Grains and dried Distillers' Grains are also balanced for milk production and are used for the purpose in feeding cows and ewes. Similar precautions against over-feeding should be exercised. The grain may be fed to other cattle, sheep and horses up to about 30 per cent. of the concentrate portion of the ration.

Beans and Peas—These foods are nearly as high in starch equivalent value as the cereals, they are richer in protein. The protein of beans and peas have a biological value for milk production as good as fresh or dried autumn grass. Whilst poor suppliers of calcium they are rich in phosphorus. Beans and peas may be fed to all types and classes of stock.

Decorticated Ground Nut Cake or Meal—Is very rich in protein, very palatable and safe. It may be fed to all classes of stock. In common with all the high protein foods it has to be properly balanced with more starchy low protein foods. The biological value of the protein is high and it is a food much used for milk production. It is not rich in minerals and if it forms the sole high protein food in a ration a suitable mineral mixture should be added particularly for milking and growing stock. This applies equally to all the high protein foods of vegetable origin.

Soya Bean Cake and Meal—A very palatable and safe food of high protein content but low in minerals when compared with Fish Meal. It may be fed to all classes of stock with good results. Depending on the class of stock it has to be adequately balanced by low protein high energy foods.

Decorticated Cotton Cake or Meal—These two foods are both rich in protein with an S.E. P.E. ratio of approximately 2 : 1. Neither are very palatable. They are not really suitable foods for sheep under about four months or cattle under six months of age. Neither should be fed in other than small quantities to pigs, young stock or pregnant stock because of the presence of gossypol. Decorticated Cotton Cake and Meal are somewhat costive.

Blood Meal—Is a high protein food whose proteins are of high biological value. It has a very small percentage of minerals. Being a very concentrated food it should be used in moderation and if it is replacing protein foods of higher ash percentage a mineral mixture will have to be used.

Meat Meals and Meat and Bone Meals—The food value of meat meals is variable. The maximum protein content being about 65 per cent., the minimum in the region of 40 per cent. Being of animal origin the proteins are of high biological value and the food itself readily digested. Meat meal, very high in protein and in fat, contains only a small amount of mineral matter but low fat meat meal may contain approximately

19 per cent. ash. Both forms of meat meal are palatable and safe. It is a food well suited to pigs and poultry and to young growing cattle and sheep. Because of its cost and scarcity it usually only forms a small part of the ration.

Meat and bone meal is less rich in protein but richer in mineral content. Because of this valuable content of calcium and phosphorous meat and bone meal is of particular value for young stock.

Whale Meal—A palatable high protein food readily eaten by stock. It is not as rich in protein as fish meal but approximately the same as low fat meat meal. It contains a useful percentage (16) of ash. It is commonly used in lieu of fish meal as a constituent of pig meals both for feeders and breeders.

Palm Nut Kernel Cake or Meal—Like Coconut Cake, Palm Kernel Cake is suitably balanced for feeding as a milk producing food. It is a food that has not very much taste and should be introduced into a ration gradually. It produces a hard white body fat but there is no clear evidence that it will increase the content of fat in milk. It can be fed to all classes of stock but should be used moderately in the rations of pigs not exceeding 20–30 per cent. It is a good food for poultry.

Fish Meal—There are two sorts of fish meal, white fish meal and herring meal. The former is higher in protein value, rather lower in energy value and higher in minerals. White fish meal is also lower in oil and should not contain more than 6 per cent. The proteins of both sorts are of high biological value. Thus fish meals are particularly good foods for young stock growing rapidly, milking stock and poultry. Being very high in protein content fish meals rarely exceed 10 per cent. of the meal or concentrate ration. The herring meal with higher oil content is better used for sows and boars, store cattle, milking or pregnant ewes, horses requiring additional protein whilst on hard work or cows kept for suckling calves. Good quality fish meal will have no harmful effect on quality of body fat or on milk. Being very costly it must be used with care, and properly balanced with foods high in energy, low in protein.

Coconut Cake—The ratio of S.E. P.E. in this food is such that it is suitably balanced for milk production. It is not a highly palatable food when dry. Soaking causes it to swell and also improves the taste and smell. If allowed to remain damp the food will become rancid. Its effect on body fat is to make it hard and white. No proof exists that coconut cake will increase the fat content of milk. It may be fed to all classes of cattle or sheep but it is more commonly used for dairy cows. It may also be fed to pigs in moderate amounts but preferably not to the younger animals under 12-14 weeks old.

The undecorticated form of Ground Nut Cake, Cotton Cake—These are higher in fibre than the decorticated form and lower in protein and starch equivalent. The extracted undercorticated Ground Nut Cake is still lower in energy value. These foods are more costive than the decorticated form and less suitable for pigs and poultry.

Undecorticated Cotton Cake, when available, has been much used for feeding to cattle on young grass or as a supplement to rations containing large quantities of laxative foods such as "roots."

Linseed—The cake and the meal are both quite safe and valuable foods for all classes of stock. If fed in excessive amounts they may cause the fat of, for example, bacon pigs to be soft and yellow. When used as a constituent of calf gruels care should be taken to boil. Merely warming the gruel may result in production of prussic acid.

Separated Milk—The energy value of this food is approximately half that of milk whilst the protein equivalent is about the same as that of milk. Thus if it is used as substitute for milk in the ration of calves the energy deficiency must be made good. Such food as oats, flaked maize and cod liver oil may be added to the separated milk for this purpose. For example, about ¾-lb. of oats added to each gallon of separated milk will bring the energy content of the separated milk plus oats to that of an equal quantity of whole milk. In practice it is difficult to get the young animals to eat sufficient of the energy supplement. Thus it is that growth rates of calves reared on separated milk plus energy supplement are rarely as good as the growth rates of similar calves reared on whole milk.

Whey—This by-product of cheesemaking has much less energy value than whole milk. The protein content is also much lower. Moreover, the ratio of starch equivalent to protein is wide. Where whey is used as a replacement for milk in feeding calves it is necessary to try and make good both the energy and protein deficiency. This is difficult to do in practice as the young calf is unable to eat sufficient of any dry supplement offered.

Growth rates where whey replaces whole milk in the rations of calves are rarely as good as when separated milk is used. Whey is a very useful food for fattening pigs. Care should be taken that whey is not fed sour as this may cause stock to scour.

Root and Green Crops—The S.E./P.E. ratio in swedes, turnips, mangolds is wide and they are consequently suitable as maintenance rather than production foods.

With certain precautions all are safe foods for all classes of stock. Mangolds should be stored for several weeks before being fed. Turnips should be fed to milking cows after milking to lessen the risk of taint in the milk. Roots should not be fed to calves until they are several weeks old when they may gradually replace part of the hay ration. If fed in excessive amounts to male sheep urinary calculi may develop.

In the past very large quantities were fed to fattening cattle but these days more moderate quantities such as 40–70 lb. per day are used. A typical allowance to a dairy cow may be 40 lb. per day of mangolds, or 35 lb. swedes.

Sows and boars can eat up to 20–30 lb. per day of swedes and mangolds and fattening pigs 5–15 lb. per day depending on their size.

It must be remembered particularly in feeding these large amounts to breeding pigs and fattening pigs that mangolds and swedes are all low in protein and minerals and the protein and mineral content of the meal must be suitably adjusted.

Sugar Beet Tops and Fodder Beet Tops—The leaves and the crown of the beet are very digestible and high in food value. Care should be taken to keep the tops as free from soil as possible. As the leaves contain oxalates or oxalic acid they should be allowed to wilt for at least a week before being fed. If the tops are fed before wilting the stock should receive ¼-lb. precipitated chalk per 250 lb. of tops. The tops are somewhat laxative. They may be fed to all classes of stock as a root substitute, about 25 lb. tops being able to replace 40 lb. mangolds. Cows may receive up to 30–40 lb. per day, well grown sheep 12–15 lb. per day. Pigs may also receive tops although they are not suitable for pigs below 80–90 lb. live weight.

When decomposition has set in the tops should be ploughed in.

Fodder Beet—Has a dry matter content considerably higher than the root crops. It may be fed to all classes of stock. There is at present more information of its value to pigs than to other stock. Approximately 5 lb. of Fodder Beet can replace 1 lb. Barley Meal. Its effect on quality of fat is to produce a hard fat with a low iodine number. It should not be fed to young pigs below 70–80 lb. live weight and its introduction into the ration should be gradual. As with other roots its deficiency in minerals must be made good in the ration. It has a higher food value than mangolds or swedes and may replace them in rations of all classes of stock.

Potatoes—Potatoes can replace cereals and root crops in the rations. Raw potatoes are a little bitter with a laxative action and if used in excess will cause blowing and scouring. Sprouted tubers should not be fed raw. Raw potatoes are not suitable for young stock, or animals in late pregnancy. Only very small amounts should be fed to horses. Fattening cattle may have up to 40–50 lb. per head day, dairy cows up to 20–30 lb. per day and sheep up to 4 lb. per day at 100 lb. live weight; 2 lb. mangolds or swedes may be replaced by 1 lb. raw potatoes. The introduction of raw potatoes into the ration must be gradual.

Potatoes should be cooked for feeding to pigs and young and pregnant stock, 4 lb. potatoes being able to replace 1 lb. cereal meal. A useful system to utilise potatoes for fattening pigs is to feed an all-meal ration to the young pigs until they are receiving 2½–3 lb. meal per day. From this time maintain meal ration constant and feed increasing amounts of potatoes up to 15–20 lb. per day. As potatoes are deficient in minerals they should be mineralised prior to feeding or a suitable mineral supplement added to the meal.

Cooked potatoes may form a substantial part of the ration of poultry. Birds should be able to consume 4 oz. per day with 4 oz. of dry food.

Potatoes can be utilised as potato silage.

Cabbage—The open leaved type has a higher food value than the drumhead. Cabbages are a safe and palatable food for all classes of stock. Dairy cows may receive 50–60 lb. per day. If large quantities are being given to cows they should receive them after milking to obviate risk of taint. Cabbages may be fed to pigs and poultry but are not a major part of the ration. Greater use could be made of this green crop for pigs particularly if it is boiled or steamed. For example pigs could receive a meal allowance increasing to 4 lb. per day at 150 lb. live weight with cabbage fed to appetite after 60–70 lb. live weight.

Kale—Kale is a safe and palatable food for all classes of stock, although for pigs and poultry it is usually regarded as a form of tonic food. When fed to sheep it is usually folded over. It is not suitable for fattening lambs due to its low dry matter. For cattle it may be cut and carted or folded. The latter practice will reduce the total cost of the crop. Dairy cows may receive 50–60 lb. per day if required. For young growing cattle it is a valuable source of minerals and a useful food as part of their maintenance ration. A fattening teg of 100 lb. live weight could receive 12–14 lb. kale per day in addition to some hay. A ewe with lambs will eat about 140 lb. per week. Horses will eat kale readily. A ration of 10 lb. hay per day with 65 lb. kale will enable a steer of 8 cwt. to put on 2 lb. live weight gain per day. Kale can be used for pigs if it is chopped to a fine pulp, introduced only to pigs over 60–70 lb. live weight and fed up to 14–16 lb. per day at 170–180 lb. live weight. About 8 lb. of well chopped kale is able to replace 1 lb. pig meal.

Straws—All straws are deficient in minerals and proteins. Oat straw has a higher food value than the other cereal straws, wheat has the lowest value. Oat straw may be fed to fattening cattle and is particularly useful if they are receiving large quantities of roots. It may be fed to low yielding dairy cows. Young stores may receive substantial amounts but care should be taken to see that the protein and mineral content of the ration is adequate for their growth. Oat straw may replace a small part of the hay ration of idle horses. Barley straw is not as good a food as oat straw but may be fed to the same groups of stock for them to pick over.

Wheat straw is generally used as bedding but may be given to well grown store cattle. It should not be given to horses.

Bean and pea straws if harvested early and well are very useful feeding stuffs. If beans have fully ripened prior to harvest the straw will be of little value as a food, being hard, indigestible and unpalatable.

Grassland—The term grazing land refers to a wide variety of swards of very different feeding value and productivity. Really good grassland will in the summer fatten one bullock and two sheep to the acre, or if well managed and efficiently grazed provide the daily needs for a cow yielding five gallons of milk. At the worst on hills and mountains several acres may be needed to support one sheep. Whilst some pastures may yield 12–13 tons of fresh grass per acre in a season, others may only produce two to three tons.

Not only does the feeding value of grassland vary from field to field but it varies also in the same field from year to year and during a single year. Grass is most nutritious when it is young, leafy and growing fast. This stage is usually during spring and early summer. Throughout the summer a steady fall in food value takes place though this fall may be greatly lessened by good grazing management and manuring.

S. J. Watson classifies pasture grass under five categories based on the degree of leafiness and stemminess in the herbage.

TABLE 107

Type.	D.M. per cent.	S.E. per cent.	P.E. per cent.
Very leafy	18	10·8	2·8
Leafy	19	11·3	2·2
Early flowering stage ...	21	12·2	1·9
Flowering stage	23	12·7	1·5
Full flower	25	12·8	1·2

The mineral content of herbage is also variable. A herbage with a good mixture of grasses and clovers will usually contain adequate minerals for the needs of all stock, except possibly very high yielding cows.

Grassland is also a valuable source of vitamins of which carotene the precursor of vitamin A is the most important.

The proteins of grass are of high biological value. It should be noted that the analysis of pasture is not always a true reflection of its value for autumn grass is in practice of poorer value than its analysis would indicate.

Silage—The following table gives the starch equivalent and protein equivalent values of various classes of silage (S. J Watson).

TABLE 108

Food	D.M. per cent.	P.E. per cent.	S.E. per cent.
Clover	20	2·1	8·9
Leafy grass	20	2·0	12·4
Grass at early flowering stage	25	1·4	14·5
Lucerne	17	2·0	7·0
Maize	20	1·0	12·1
Marrow stem kale ...	16	1·3	9·8
Potato	25	1·1	18·6
Vetch and oat	25	1·4	10·8
Sugar beet tops	25	0·9	10·8

In feeding practice silage can be considered as of three main types—first quality, second quality and third quality.

First quality silage can be made from grass, clover, lucerne, sainfoin and kale cut when young and leafy, the legume being in the early bud stage.

Second quality can be made from grasses and clovers, lucerne, sainfoin and kale cut rather later. Also from cereal legume crops cut when the oats are in the milky stage.

Third quality silage being made from any of the above crops cut at a more mature stage of growth.

The Ministry of Agriculture make the following suggestions for the feeding of silage :

First quality (per gallon of average quality milk) :

20 lb. grass and clover silage or
25 lb. clover silage or
30 lb. kale silage.

Second quality—Lying midway in food value between hay and cake may be used to replace some of each of these two foods.

20 lb. of such silage replaces 5 lb. hay plus any of the following :

1¾ lb. beans or peas.
1¾ lb. palm nut kernel cake.
1¾ lb. coconut cake.
1¾ lb. balanced milk production.

Third quality silage is a hay or root replacement.

Other examples of the use of silage are given on later pages.

Silage may be fed in one form or another to all groups of stock.

The quantities that may be fed to dairy cows have already been given on previous pages.

Fattening cattle may receive moderate amounts of 30–50 lb. per day or may, it appears from recent experiments, be fattened entirely on silage, receiving 120–126 lb. per head per day. Store cattle may have 20–40 lb. per day in winter in lieu of hay and roots or if silage is of good quality in lieu of cake and meal.

A ewe may receive up to 10–12 lb. per day of good quality silage when she is either in or with lamb.

Fattening tegs may also receive several pounds per day. Pigs will normally receive potato silage but sugar or fodder beet tops may also be fed to them as these are low in fibre.

Working horses may be given up to 20–25 lb. per day.

Silage should be introduced into a ration gradually. The amount that is needed each day should be removed from the silo either daily or every second day. Utensils from which silage is eaten should be cleaned daily.

Dried Grass—The nutritive value of dried grass and dried lucerne is shown in Table 109 (S. J. Watson).

TABLE 109

Type of Product	D.M. per cent.	S.E. per cent.	P.E. per cent.	D.C.P. per cent.
Very leafy grass ...	90	54·1	13·6	14·1
Leafy grass	90	51·7	9·3	10·0
Lucerne, bud stage ...	91	50·1	13·6	15·9
Lucerne, early flowering	91	44·1	10·5	11·6

These foods are useful sources of minerals and, if well made and well stored, of vitamin A.

The following table (R. E. Slade) shows how dried grass and dried lucerne may be used for the production of milk.

TABLE 110

	Weight to feed for each gallon of milk lb.
High protein grass silage	20
Dried grass (crude protein, per cent. 14)	6
„ „ („ „ „ „ 15)	5⅓
„ „ („ „ „ „ 16)	4⅚
„ „ („ „ „ „ 17)	4¾
„ „ („ „ „ „ 18)	4⅓
Oats, 45 lb., and dried lucerne (crude protein, per cent. 23) 35 lb.	4⅙
Oats, 45 lb., and dried lucerne (crude protein, per cent. 22) 40 lb.	4⅕
Oats, 45 lb., and dried lucerne (crude protein, per cent. 21) 43 lb.	4¼
Oats, 45 lb., and dried lucerne (crude protein, per cent. 20) 48 lb.	4½
Oats, 45 lb., and dried lucerne (crude protein, per cent. 19) 54 lb.	4⅝
Oats, 45 lb., and dried lucerne (crude protein, per cent. 18) 63 lb.	4¾
Oats, 45 lb., and dried lucerne (crude protein, per cent. 17) 74 lb.	5
Oats, 45 lb., and dried lucerne (crude protein, per cent. 16) 90 lb.	3
Potatoes, 70 lb., and dried lucerne (crude protein, per cent. 20) 48 lb.	8¼
Sugar beet pulp (dry) 30 lb., and dried lucerne (crude protein, per cent. 20) 48 lb.	5
Sugar beet pulp (dry), 30 lb., and fresh brewers' grains, 110 lb.	10
Straw pulp (dry), 30 lb., and fresh brewers' grains, 110 lb.	18
Oats, 45 lb., and fresh brewers' grains, 110 lb.	8
Dry sugar beet pulp, 30 lb., and fish meal, 4½ lb.	4
Oats, 45 lb. and fish meal, 4½ lb.	4

Dried grass may be fed to all classes of stock. Calves may have part if not all the concentrate portion of their ration replaced by high quality dried grass or dried lucerne. The inclusion of 10 per cent. of dried grass or lucerne meal in the ration of pigs is a valuable addition to their diet and has a tonic effect.

Medium quality material can be used for fattening cattle, 12–14 lb. would supply adequate maintenance ration starch equivalent for a 9 cwt. beast and two-thirds of its total protein requirement.

Hay—There are several sorts of hay. Meadow hay from permanent grassland, seeds hay from temporary grass, clover hay, lucerne and sainfoin hay. A mixture of oats and tares may also be naturally dried to form hay. Timothy may be grown as a pure seeding for making into hay. The nutritive value of any one of the above sorts of hay is very variable and depends a great deal on the stage of maturity of the crop when cut. Some loss of nutrient value is inevitable in hay making, the extent of the loss varying with the weather during hay making and the efficiency with which the process is carried out.

The following table gives the starch equivalent and protein equivalent of certain samples. It must be realised that these figures are only guides.

TABLE 111

	D.M. per cent.	S.E. per cent.	P.E. per cent.
Good meadow hay ...	85·7	37	4·6
Sainfoin (in flower) ...	83·5	37	8·6
Tare and oats	84·0	34	5·4
Seeds hay	84·8	38·4	6·4
Lucerne (full flower) ...	83·5	29	8·0

The majority of hays have a wide S.E./P.E. ratio and can only be regarded as bulky maintenance foods which are fed to all classes of ruminants and horses.

Lucerne or sainfoin hay of good quality have considerably higher protein equivalents than meadow or seeds hay and lower starch equivalents. Thus the ratio of S.E. : P.E. will be narrower and these quality hays may be used as production foods.

Preparation of Food Stuffs. PULPING—Unless it is the intention to persuade animals to eat very large quantities of roots it is unnecessary to pulp them except for broken mouthed sheep and when fattening pigs are receiving several pounds per day as in the Lehmann system of feeding.

CHAFFING—It is desirable to mix some chaffed straw with the concentrate ration fed to horses. They will then chew the food properly and not bolt it. Chaffing of straw for other stock is not a very good practice unless done on purpose to ensure large quantities of straw are consumed. It is in fact better feeding practice to give straw long so that stock may eat the more nutritious parts and leave the woody stemmy parts.

Cutting up of green crops such as kale for feeding to housed or yarded stock is a useful way of reducing wastage.

SOAKING—There are several reasons why food may be soaked prior to feeding :

1. To reduce wastage by blowing away of food.
2. To render dusty foods less troublesome to beasts.
3. To reduce the risk of digestive disorders from consumption in the dry state of foods that will swell a great deal when wet.
4. Certain foods are more palatable when soaked.
5. Certain foods, e.g., bran, have a laxative effect when fed as a mash.

COOKING—There is no evidence that cooking of foods for stock is necessary or desirable except as follows.

Raw potatoes may cause digestive troubles, cooking renders them much more readily digested. They should always be cooked for feeding to pigs. Cattle eat raw potatoes best but only moderate amounts of the raw food should be fed to young and pregnant animals. This applies also to sheep.

Swill must be boiled if for no other reason than to comply with the law. If linseed is used as a constituent in gruels then the gruel must be boiled. The use of warm water that has not boiled is very dangerous.

CRUSHING AND GRINDING—Whether foods should be crushed or ground depends somewhat on the class of stock to which the food is given. Young calves under six months relish whole grains and chew them well. It is usual to grind food for pigs because of the animals digestive system. Grains for gruel feeding will be ground. For other classes of cattle, for horses and sheep cereals will normally be crushed or rolled and beans and peas cracked. The grinding of roughages for cattle and sheep does not increase digestibility. In fact the reverse may occur. Grinding of foods to an over-floury consistency increases the pastiness to an extent that the animals dislike and reduces the palatability.

The grinding of dried grass and dried lucerne produces a valuable food for inclusion in moderate amounts in the rations of pigs and poultry.

Certain general rules of good feeding practice should be borne in mind by all whose responsibility it may be to care for livestock.

The ration as a whole must be so designed that it is suited to the digestive system of the animal eating it. Stock with large digestive systems, the horse, cattle and sheep need rather bulky rations to ensure sufficient digestion and a satisfied feeling. Young animals cannot be expected to consume a great deal of bulk. Excessive feeding of bulky foods such as straw and hay to dairy cattle may produce a fall in milk yield and a watchful eye must be kept on the total dry matter and fibre content of their ration. Young stock eating excessive quantities of moderate value bulky foods such as roughages may become stunted and pot bellied. On the other hand ruminants should be encouraged to eat adequate quantities of bulky foods in order to develop a good digestive system.

Pigs need a more concentrated ration although their ability to utilise efficiently certain bulky foods such as roots is greater than was previously thought.

Feeding must be carried out with regularity. Failure to adhere to the proper times each day has an unsettling effect on animals. When animals are being hand-fed they should have at least two meals a day. Very young stock, high yielding cows and fattening cattle should be fed more frequently than that. Not only should the meals be at the proper times but the quantities fed should not change from day to day. Any changes made in rations either of quantity or make-up should be made gradually over a period of some days.

In addition to supplying, so far as it is possible to determine, the energy, protein, minerals and vitamins needed by the animal the ration must be palatable. It should be slightly laxative rather than costive. Mixtures of cereals and meals should be in a suitable mechanical or physical condition for the particular class of animal. Thus crushed foods are better than ground for cattle, sheep and horses, whilst pigs are usually fed on ground meals. Foods that are over-mealy and over-floury become pasty when masticated and are not enjoyed. Flaky foods help to " lighten " an otherwise heavy mixture.

It is most important that there is adequate feeding space for each animal. Considerable waste of energy can result from animals struggling for feeding room. Troughs, cribs, mangers, buckets and any other feeding utensils must be cleaned frequently. With young stock particularly it is important to give only small quantities of food at a time. Stale food that stock have mouthed over will not be eaten.

Certain foods can produce tainted milk or flesh. Milk taints may be " internal " that is due to a food that a cow has eaten or " external " due to the odour of the food in the milking place. Foods such as cabbage, kale, rape, turnips, swedes and beet tops which can cause internal taints should be fed in moderate amounts and immediately after milking. Silage, if fed in the cowshed just prior to or during milking, may cause an external taint. In the feeding of pigs high oil content fish meal should not be fed to bacon or pork pigs though it may be used for breeding stock. Low oil content fish meal in the normal amounts may be safely used for fatteners.

All animals are individuals ; this should never be forgotten. General rationing schemes may be drawn up for a group of stock but the good stockman will watch the individual and be prepared to make any necessary adjustments.

Finally, in devising rations, the cost must always be borne in mind for the cost of the food is a major part of the total production cost of all animal products.

The Construction of Rations—Below are two examples of how to use the feeding standards given on page 340 to page 347 to prepare rations.

The first ration is for a dairy cow.

It is required to construct a ration using hay, mangolds, oats, palm nut kernel cake, decorticated ground nut cake and flaked maize for a cow weighing 1,000 lb. live weight yielding three gallons of 3·75 per cent. butter fat milk daily. For the maintenance part of the ration use hay and mangolds. The starch equivalent and protein equivalent of these two foods is as follows :—

	S.E.	P.E.
Meadow hay	37·0	4·6
Mangolds ...	6·2	0·4

The cow needs each day for maintenance 6 lb. starch equivalent including 0·6 lb. protein equivalent.

	S.E. lb.	P.E. lb.
10 lb. hay supplies ...	3·70	0·46
40 lb. mangold supplies	2·48	0·16
	6·18	0·62

The dry matter of this part of the whole ration is 9·79 lb. thus leaving approximately 15 lb. dry matter in which to supply the production ration.

The starch equivalent and protein equivalent values of the production foods are as follows :—

	S.E. per cent.	P.E. per cent.
Oats	59·5	7·6
Flaked maize	84·0	9·2
Beet pulp	60·6	6·1
Decorticated ground nut cake	73·0	41·3

	lb.	S.E. lb.	P.E. lb.
Oats	200	119·0	15·2
Flaked maize	100	84·0	9·2
Beet pulp	100	60·6	5·1
Decorticated ground nut cake ...	100	73·0	41·3
		336·6	70·8

The ratio of starch equivalent to protein equivalent of this mixture is for all practical purposes correct.

In 100 lb. of this mixture there is :—

67·3 lb. S.E. and
14·1 lb. P.E.

2·5 lb. starch equivalent will therefore be contained in 3·9 lb. meal.

0·55 lb. protein equivalent will be contained in 3·9 lb. meal.

Just under 4 lb. of this meal contains the necessary nutrients for one gallon of milk.

12 lb. of this meal contains approximately 10¾–11 lb. dry matter which, when added to the maintenance rations, is within the capacity of the cow.

The second example shows a ration suitable for a steer being fattened.

An animal weighing 9 cwt. is required to put on approximately 2 lb. live weight gain per day in the middle stages of the fattening period.

The daily maintenance requirement for such an animal is 6 lb. starch equivalent including 0·6 lb. protein equivalent.

The energy requirement for a live weight gain each day of 2 lb. is 3 lb. starch equivalent per 1 lb. live weight gain.

The protein equivalent in the whole ration should be about one-eighth of the total starch equivalent.

Thus—

	S.E. lb.
Maintenance daily	6
2 lb. live weight gain daily ...	6
Total ...	12

Total protein—12 divided by 8=1·5 lb.

Foods available—

	S.E. per cent.	P.E. per cent.
Swedes	7·3	0·7
Oats	59·5	7·6
Flaked maize ...	84·0	9·2
Oat straw	20·0	0·9
Coconut cake ...	76·8	16·4
Linseed cake	74·0	25·1

The following can be used :—

		S.E. lb.	P.E. lb.
Swedes, 60 lb.	...	4·38	0·42
Oat straw, 12 lb.	...	2·40	0·11
		6·78	0·53
Deficiency	=	5·22	0·97

This can be made good as follows :—

	lb.	S.E. lb.	S.E. lb.
Coconut cake	200	153·6	32·8
Oats	200	119·0	15·2
Flaked maize	200	168·0	18·4
Linseed cake	200	148·0	50·2
Mixture contains	800	588·6	116·6
Mixture has	100	73·6	14·6

The ratio is about the same as the S.E. P.E. ratio in the deficiency, i.e., 5 : 1.

If 100 lb. supplies 73·6 lb. starch equivalent and 14·6 protein equivalent, 7 lb. supplies 5·152 lb. S.E. and 1·02 lb. P.E.

Thus the ration is :—

	(lb.)	S.E. (lb.)	P.E. (lb.)
Swedes	60	4·38	0·42
Oat straw	12	2·40	0·11
Concentrates	7	5·15	1·02
		11·93	1·55

There is a small deficiency of starch equivalent which may be made good by increasing swedes to 70 lb. per day.

The whole ration will contain approximately 24–25 lb. of dry matter.

The following rations are only examples of the many that may be given to different groups of stock.

They may be arrived at by means of calculation such as in the two examples given or by a simpler system similar to the food unit system which is given here by permission of S. J. Watson and which is based on starch equivalents.

Starch equivalent and protein equivalent requirements for maintenance are shown in Table 98 on page 340.

It will be seen that the S.E./P.E. ratio is approximately 10 : 1. If the maintenance requirements of a 300 lb. beast is termed a maintenance unit the number of maintenance units required by stock of greater or lesser weights is shown below.

TABLE 112

Maintenance Units for Cattle

Live Weight	Maintenance Units per day (approx.)
60 lb.	¼
100 lb.	½
140 lb.	½
200 lb.	¾
300 lb.	1
400 lb.	1¼
600 lb.	1½
800 lb.	2
1,000 lb.	2½
1,200 lb.	2¾
1,400 lb.	3

Production Requirements—The starch equivalent required to produce a gallon of average quality milk, the first pound of growth, or a pound of live weight gain in the early fattening stages is in each case approximately 2½ lb.

Thus there are two sorts of units the one a maintenance unit containing approximately 2½ lb. S.E. and about 0·25 lb. protein equivalent, the other a production unit containing approximately 2½ lb. S.E. and about 0·5 or 0·6 lb. protein equivalent.

Clearly calculations can be made to show what quantity of any given food will supply 2½ lb. starch equivalent and what quantity of protein equivalent will also be supplied in that amount of food.

The following are some examples :—

TABLE 113

Food	S.E./P.E. ratio	Amount per unit	S.E. lb. in 1 unit	P.E. lb. in 1 unit
Leafy pasture grass	5	22	2·48	0·48
Cabbage	7	38	2·50	0·34
Meadow hay ...	11	7	2·49	0·22
Mangold	15	40	2·48	0·16
Decorticated ground nut cake	2	3½	2·54	1·44
Linseed cake ...	3	3¼	2·41	0·80
Coconut cake ...	5	3¼	2·51	0·54
Grass silage ...	4	20	2·48	0·56

The table shows that high protein grass silage has a suitable S.E./P.E. ratio for a milk production food and that 20 lb. will supply adequate energy and protein for the production of one gallon of milk. In other words 20 lb. of this sort of silage is one production unit. If high fat milk is being produced approximately one-sixth more should be fed, i.e., about 24 lb.

Meadow hay with a S.E./P.E. ratio of 11 : 1 is a suitable maintenance food and 3 units totalling 21 lb. will be adequate for a 1,400 lb. beast. 21 lb. hay of this quality will supply approximately 7½ lb. S.E. and just under 0·7 lb. of protein equivalent.

The examples below illustrate the use of this system.

1. A ration for cattle a little over 7 cwt. in a store condition and required to increase in weight by 1 lb. per day should consist of 2 maintenance units and 1 production unit.

1 maintenance unit = 7 lb. meadow hay.
1 maintenance unit = 28 lb. kale (marrow stem).
1 production unit = 20 lb. leafy grass silage.

2. A ration for a cow weighing 1,000 lb., yielding 4 gallons of milk :—

Maintenance units required = 2½.
Production units required = 4.
1½ maintenance units = 11 lb. meadow hay (early flowering).
1 maintenance unit = 28 lb. marrow stem kale.
4 production units = 80 lb. high protein silage.

3. A ration for a 1,000 lb. or 9 cwt. beast being fattened :—
Maintenance units required = 2½.

Production unit for first lb. of gain = 1.
Second lb. of gain requires a further 1½ maintenance unit.
2 maintenance units = 80 lb. mangold.

½ maintenance unit = 5–6 lb. oat straw.

1 production unit = 3½ lb. of a production mixture (see below).

½ maintenance unit = 5–6 lb. oat straw.

1 maintenance unit = 4¼ lb. crushed oats.

Production Mixture—

1 part of oats.

2 parts of barley.

1 part of decorticated ground nut cake.

Complete ration then—Mangold, 80 lb.
Oat straw, 10–12 lb.
Crushed oats, 4¼ lb.
Production mixture, 3½ lb.

The following table illustrates rations for dairy cows when it is desired to make the maximum use of high quality home grown foods.

The foods used are as follows :—

1. High quality grass silage. 20–25 lb. of such silage is adequate for the production of 1 gallon of milk of average fat quality. 50 lb. will be adequate for the daily maintenance of a 9 cwt. cow.
2. Good quality hay. 17–18 lb. daily will supply the maintenance requirements of a 9 cwt. cow.
3. Marrow stem kale. 70 lb. daily will supply the maintenance requirements of a 9 cwt. cow.
4. Oats and beans. 4 lb. of a mixture of equal parts of these two foods will supply adequate nutrients for 1 gallon of milk of average quality.
5. High protein dried grass. 5 lb. will supply the nutrients for 1 gallon of milk of average quality.

TABLE 114 RATIONS FOR A 9 CWT. COW AT VARIOUS MILK YIELD LEVELS.

	Maintenance plus 1 gallon				Maintenance plus 2 gallons				Maintenance plus 3 gallons				Maintenance plus 4 gallons			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	lb.				lb.				lb.				lb.			
Hay ...	14	11	7	—	14	11	7	—	14	11	11	—	11	11	—	—
Kale ..	—	28	42	—	—	28	42	—	—	28	28	—	28	—	—	—
Silage ...	30	20	20	70	50	40	40	90	30	40	60	110	20	40	70	130
Oats and beans	—	—	—	—	—	—	—	—	—	—	—	4	—	4	—	—
Dried grass	—	—	—	—	—	—	—	—	10	5	—	—	15	10	15	—

Note—*If the milk is of Channel Island quality the amount of production ration should be increased by one-fifth to one-sixth per gallon. Smaller breeds will of course require less maintenance food. With smaller breeds yielding milk of very high quality the total bulk of the ration must be closely watched.*

The Rationing of High Yielding Dairy Cows—The follo table based on the method suggested by R. Bout gives a method of controlling the quantity of bulk or dry m in the rations of high yielding cows weighing 11 cwt. :—

TABLE 115

Ration for High Yielding Cows

	Gallons						
Yield/Day	1	2	3	4	5	6	7
Food	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Hay	17	17	17	15	14	12	9
Silage	20	40	40	40	40	40	40
Concentrates ...	—	—	3½	7	10½	14	17½

Cropping for Milk Production—The following requiren per cow are suggested by H. I. Moore :—

Kale	⅛-acre.
Oats	¼-acre.
Silage or roots	½-acre.
Seeds and hay	¾-acre.
Grazing	¾-acre.
	2⅜ acres.

TABLE 116. RATIONS FOR DAIRY COWS BASED ON CROPPING OUTLINED PAGE 368

	Group A							Group B					Group C				
	Cows giving up to one gallon of milk daily. Daily rations in lb.							Cows giving from one to two gallons of milk daily. Daily rations in lb.					Cows giving from two to three gallons of milk daily. Daily rations in lb.				
	1	2	3	4	5	6	7	1	2	3	4	5	1	2	3	4	5
Hay (medium quality) ...	14	14	10	10	—	10	14	17	17	10	20	20	14	14	14	14	14
Oat straw	7	7	10	10	20	7	7	—	—	—	—	—	—	—	—	—	—
Kale	45	—	28	—	50	28	—	60	—	35	—	—	35	—	—	—	—
Roots	—	55	—	40	—	—	25	—	60	—	—	—	—	50	—	—	—
Oat and tare silage ...	—	—	—	—	—	25	25	—	—	—	—	25	—	—	25	—	—
Grass silage	—	—	—	—	—	—	—	—	—	25	50	—	—	—	—	25	40
Oats	—	—	3	4	5	—	—	—	1	4	—	2	3	3	3	3	3
Balanced production Mixture	—	—	—	—	—	—	—	—	3	—	—	2	8	8	8	7	4

Grouping of Foods for ease in making up Rations for Milk Production (Boutflour).

GROUP I

(Foods already balanced for milk production)

Compound cakes.
National dairy cake No. 1.
Palm kernel cake or meal.
Coconut cake.
Weatings.
Bran.
Dried brewers' grains.
Dried grass (over 14 per cent. protein).
Dredge corn with at least 30 per cent. peas and/or beans.

GROUP II

(Mix 1 part with 1 part of any food in Group VI)

National dairy cake No. 2.
Linseed cake.
Peas and beans.
Distillers' dried grains.
Maize gluten feed.
Malt culms.
Undecorticated cotton cake.
Sunflower seed cake.

GROUP III

(Mix 1 part with 2 parts of any food in Group VI)

Undecorticated groundnut cake.
Maize gluten meal.
National grain balancer (cake or meal).

GROUP IV

(Mix 1 part with 3 parts of any food in Group VI)

National high protein cake or meal.
Decorticated groundnut cake or meal.
Decorticated cotton seed cake or meal.
Soya bean cake or meal.

GROUP V

(Mix 1 part with 5 parts of any food in Group VI)

White fish meal.
Feeding quality meat meal.
Dried yeast (in limited quantities only).

GROUP VI

(Cereal Foods)

Maize meal.
Maize germ meal.
Crushed wheat, rye, barley or oats.
Dredge corn with less than 30 per cent. peas and/or beans.
Flaked maize.
Locust beans.
Tapioca meal.
Dried sugar beet pulp.
Molasses.
Dried potato products.

Calf Feeding.—The rationing schemes shown below are those recommended by the Survey Committee of the National Veterinary Medical Association, 1947, for calves reared on the pail or bucket.

TABLE 117. REARING WITH WHOLE MILK.

Week	Whole Milk Pints	Water pints	Hay	Con-centrates
1–3 days on cow	—	—	Good	—
Starve 12 hours	—	—	meadow	—
To 7th day ...	6	—	hay	—
2nd week ...	8	—	available	—
3rd week ...	8	—	in	2–4 oz.
4th week ...	8	—	increasing	4 oz.
5th week ..	8	—	amount	½-lb.
6th week ...	7	1	to	1 lb.
7th week ...	6	2	satisfy	1½ lb.
8th week ...	6	2	the	2 lb.
9th week ...	5	3	calf	2 lb.
10th week ...	4	4		2 lb.
11th week ...	3	5		2½ lb.
12th week ...	2	6		3 lb.
13th week ...	—	6		3 lb.
14th to 18th week	—	ad lib		3 lb.
18th to 26th week	—	ad lib		4 lb.

TABLE 118. REARING WITH WHOLE MILK AND MILK SUBSTITUTE.

Week	Whole milk pints	Milk Substitute pints	Water pints	Hay	Con-centrates
1–3 days on cow	—	—	—	Good	—
Starve 12 hours	—	—	—	Meadow	—
To 7th day ...	6	—	—	hay	—
2nd week ...	8	—	—	available	—
3rd week ...	8	—	—	in	2–4 oz.
4th week ...	6–4	2–4	—	increasing	4 oz.
5th week ...	4–2	4–6	—	amount	½-lb.
6th week ...	2–1	6–7	—	to	1 lb.
7th week ...	—	8	—	satisfy	1½ lb.
8th week ...	—	8	—	the	2 lb.
9th week ...	—	6	2	calf	2 lb.
10th week ...	—	6	2		2 lb.
11th week ...	—	4	4		2½ lb.
12th week ...	—	4	4		3 lb.
13th week ...	—	4	4		3 lb.
14th to 18th week	—	4	4		3 lb.
18th to 26th week	—	—	ad lib		4 lb.

Concentrates Mixtures Suitable for Feeding to Calves—The National Institute for Research in Dairying suggests the following mixtures for feeding in the dry state.

	per cent.
Broken linseed cake ...	30 to 40
White fish meal	10 to 25
Cereals	50 to 60

Such a ration as the following is based on the above.

Crushed oats	3½ parts by weight.
Flaked maize	2 ,, ,,
White fish meal ...	1½ ,, ,,
Linseed cake	3 ,, ,,

H. G. Robinson gives the following ration for feeding dry :—

	Per cent.
Crushed oats	30
Rolled barley	30
Bran	10
Linseed meal	10
Dried separated milk ...	20

The addition of cod liver oil to all calf rations is of value to ensure an adequate supply of vitamin A.

If fish meal or an equivalent quantity of high mineral content animal protein is not included in the ration then a mineral mixture should be included made up of equal parts of sterilised feeding bone flour, ground limestone and common salt at 1½ per cent. of the meal mixture.

Rations for Young Cattle—

1. Dairy heifer weighing approximately 600 lb. and required to increase in weight at about 1 lb. per day.

The dry matter capacity is approximately 15 lb.

	lb.
Hay (early flower stage)	7
Silage (high protein)	10
Dried grass (high protein)	5

2. Store animal required to increase in weight at the rate of 1½ lb. per day.

Live weight approximately 800 lb.

	lb.
Hay (early flower stage)	7
Silage (high protein)	20
Kale (marrow stem)	28
Concentrate mixture	2

Use a mixture of equal parts of oats and beans.

3. Ration for a store weighing approximately 800 lb. and required to increase in weight at about 1 lb. per day.

	lb.
Hay (early flower stage)	7
Oat straw	12
Silage	20

In lieu of 28 lb. kale the following foods may be used at the quantities shown.

	lb.
Swedes	35
Mangolds	40
Oat and tare silage	23
Sugar beet tops	30
Dried sugar beet pulp	4

Rationing Scheme for a Bullock being Fattened in the Winter—Starting weight approximately 9 cwt., finishing weight 11½ cwt.

TABLE 119

Foods	Early stage lb.	Middle stage lb.	Finishing stage lb.
Swedes	52	—	—
Mangolds	—	60	60
Hay	10–11	14	14
Oat straw	6	—	—
Oats	2¼	3¼	5½
*Mixed meal and cake	3½–4	3½–4	3½–4

***Composition of Mixed Meal and Cake**—

		Parts
Either	Decorticated ground nut cake	1
	Oats or barley	2
	Flaked maize	1
Or	Equal parts of oats and beans to be fed at 4 lb. per day.	

A fattening ration using hay and silage. The silage being partly high protein and partly more mature material.

TABLE 120

Foods	Early stage lb.	Middle stage lb.	Finishing stage lb.
Hay	11	11	11
Mature silage	55	60 to 65	65 to 70
High protein silage ...	20	20	20

Pig Rations—Ration for a pig in early fattening stage, receiving all meal.

5 lb. white fish meal.
10 lb. soya bean meal.
20 lb. Sharps.
55 lb. barley meal.
10 lb. flaked maize.

Plus a mineral mixture of ground limestone and common salt in the ratio of 3 : 1.

A RATION FOR BREEDING GILTS AND YOUNG BOARS
(H. R. DAVIDSON)

Dried sugar beet pulp ...	25	parts by	weight.
Maize meal	25	,,	,,
Linseed cake meal	10	,,	,,
Wheat bran	10	,,	,,
Barley meal	20	,,	,,
Meat and bone meal ...	10	,,	,,

A RATION FOR SUCKLING SOWS
(H. R. DAVIDSON)

Wheat middlings	40	parts by	weight.
Maize meal	50	,,	,,
Fish meal	10	,,	,,

TABLE 121

SCOTTISH STANDARD MIXTURES FOR BACON PIGS.

Rations in parts by weight.

	A	B	C
Weatings	4	3	3
Barley meal	3	3	3½
Maize meal	2	3	3
White fish meal	1	1	½

Ration A.—First 6 weeks after weaning.
Ration B.—Second 6 weeks.
Ration C.—From then until slaughter.

TABLE 122

Types of Rations for bacon pigs. (C. Crowther.)

Live Weight lb.	Cereals per cent.	Weatings per cent.	Fish meal per cent.
30 40	40	45	15
60 80 120	65	30	5
140 200	80	20	0

THE LEHMANN SYSTEM OF FEEDING PIGS.—In this system young pigs receive an all meal ration until they weigh between 50–60 lb. live weight at an age of about 12 weeks. At this weight the pig should be eating 2½ lb. of meal per day. From this stage until the pig is slaughtered the weight of meal fed remains constant. In addition the pigs are fed gradually increasing amounts of bulky foods such as swill, potatoes, fodder beet, mangolds. Sugar beet and fodder beet tops have also been used.

The protein content of the meal should remain reasonably high. A meal containing 10 per cent. fish meal or its equivalent is satisfactory. Where the bulky food fed is of low mineral content it should be mineralised. For example to each 100 lb. potatoes add

Sterilised feeding bone flour	1 part by weight.
Finely ground chalk ...	1 " "
Common salt...	½ " "

The following table illustrates quantities of meal and supplement where boiled potatoes are the supplement :—

TABLE 123
Lehmann System of Pig Feeding
Using potatoes.

Live Weight lb.	Amount of Meal per day lb.	Amount of Cooked Potatoes per day lb.
50	2½	—
80	2½	4
100	2½	6
120	2½	8
160	2½	12
200	2½	14

TABLE 124. RATIONS FOR HORSES.

The table below indicates certain alternative rations for a farm hors weighing about 15 cwt.

	Light Work			Medium Work			Heavy Wor	
	1	2	3	1	2	3	1	2
Food	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Hay ...	20	20	15	20	20	17	20	20
Oat straw ...	—	—	10	—	—	6	—	—
Oats... ...	7	5½	3	11	5	6	16½	10
Beans ...	—	—	—	—	3½	4½	—	3½
Barley ...	—	—	1¾	—	—	—	—	—
Bran ...	—	—	2¾	—	—	—	—	3½
Maize ...	—	—	—	—	1¾	—	—	—
Swedes ...	—	—	14	—	—	—	—	—

In the North of England rather more oats or other cereals will probably be fed to working horses than in the South where, as a general rule, horses are not worked so hard.

Rations for Sheep.—1. Ration for a fattening sheep weighing 100 lb. and required to increase in weight at rate of 2¼ lb. per week. Its dry matter appetite being about 2¾ lb. per day.

	S.E. lb.
Maintenance requirements per week ...	7·49
Production requirements per week ...	4·50
	11·99

Suitable S.E. : P.E. ratio 7 : 1.

Thus the animal requires approximately 12 lb. per week of S.E., including 1¾ lb. per week of protein equivalent.

	S.E. lb.	P.E. lb.
Use Swedes, 100 lb.	7·3	0·7
Red clover hay, 5 lb.	1·90	0·35
Mixed concentrates, 4 lb. ...	2·88	0·72
	12·08	1·77

The concentrate mixture is as follows :—

	Parts by weight
Oats	1
Decorticated ground nut cake	1
Beans	1
Flaked maize	1½

2. Ration for a ewe suckling lamb. Ewe weighs 140 lb. and is assumed to yield 2 gallons of milk per week.

She requires per week :—

4 maintenance units,
3 production units.

It will be remembered that ewes milk is richer than cows milk and 1½ production units should therefore be fed per gallon.

Use mangolds, medium clover hay, cake and meal mixture.
2½ maintenance units = 100 lb. mangolds.
1½ maintenance units = 10-11 lb. hay.
3 production units = 10 lb. meal and cake mixture.

The mixture suggested is :—

1 part by weight of oats
2 parts by weight of flaked maize
1 part by weight of decorticated ground nut cake.

TABLE 125. FOLDING CALENDAR FOR ARABLE-LAND SHEEP (E. T. HALNAN AND F. H. GARNER.)

TIMES OF FOLDING	CROPS FOLDED	TIMES OF DRILLING CROPS
January	Sugar-beet tops	April and May.
	Swedes	May and June.
	Turnips	July to September.
	1,000 head kale	April to August.
	Marrow stem kale	„ „
	Rape	„ „
	Mangolds	April and May.
February and March	As January except no sugar-beet tops	
April	Turnip tops	September.
	1,000 head kale	June to August.
	Rye	September.
	Winter barley	„
	Winter oats	„
	Rape	August and September.
May	Trefoil	April (previous year).
	Trifolium	August and September.
	Oats and tares	September.
	Seeds and sainfoin	April (previous year).
June	Cabbages	July and August.
	Seeds and sainfoin	April (previous year).
	Oats and tares	September and October.
July	Cabbages (2nd growth)	August.
	Seeds and sainfoin aftermaths	April (previous year).
	Mustard	May.
	Oats and tares	October and November.
August	Cabbages (2nd growth)	August and February.
	Seeds and sainfoin aftermaths	April (previous year).
	Marrow stem kale.	February to April.
	Mustard	May and June.
	Oats and tares	March and April.
	White turnips	April.
	Kohl rabi	April.
September	Cabbages	April and May.
	Mustard	June and July.
	Seeds and sainfoin	April (previous year).
	Marrow stem kale	March and April.
	White turnips	May.
	Kohl rabi	April and May.
October	Cabbages	April and May
	Mustard	July and August.
	Seeds and sainfoin	April (previous year).
	Rape	June.
	Kale (marrow stem)	April and May.
	White turnips	July.
	Sugar-beet tops	April and May.
November and December	As October.	

FEEDING OF STOCK AT PASTURE

During the winter stock are rationed on certain scientific principles. When stock are at grass during the summer to ration with the same exactness is not possible. The following are the reasons for this.

The food value of grass is very variable both from field to field and in the same pasture at different seasons of the year. To assess the food value of a pasture at any one time is by no means easy. Experience and observation of pasture and stock will in time enable a grazier to assess its value with reasonable success. Milk recording and sound interpretation of the daily yields is of considerable assistance in evaluating the food value of pastures.

Another considerable difficulty is that little is known for certain regarding the amount of herbage consumed by different types of stock. Experimental evidence is at times contradictory on this matter.

The Feeding of Fattening Cattle on Grass—A first class pasture should provide sufficient food nutrients to enable a mature beast to increase in live weight by approximately 2 lb. per day.

When towards the end of the summer the grass is rather less nutritious the form of supplementary food given should be low in protein for the protein requirement for fattening cattle is not high. The following foods are suitable : cereals, maize germ cubes, dried sugar beet pulp.

Later on in the season a small amount of moderate protein food may also be given.

The Feeding of Dairy Cows during the Summer—The grazing of pastures rotationally on the on and off system, for example, by the means of the electric fence ensures that the herbage is eaten at its most nutritious stage and is then given an adequate period for unchecked growth. By these means dairy cows may move during the summer from one pasture to another, each pasture carrying young herbage of high feeding value.

Under the best condition of weather and grazing management young leafy herbage should provide enough starch equivalent and protein equivalent to maintain a 9–10 cwt. cow and satisfy the requirements of a 5 gallon milk yield per day. Under less good conditions pasture intensively grazed should be able to supply adequate food nutrients to satisfy the requirements of a 9–10 cwt. cow yielding 3 gallons of milk.

For yields above these quantities the supplementary food would be a balanced milk production ration.

Difficulties arise with very high yielding cows which are unable to eat what is assumed to be a full ration of grass and at the same time to consume the concentrated foods that may be offered for yields above 5 gallons. In certain cases restriction of grazing may be necessary.

Where pastures are not rotationally grazed the food value of the herbage will decline steadily during the summer.

Dry seasons will also reduce the rate of growth of fresh grass on rotationally grazed fields.

Under such conditions there will be a steadily increasing need to feed supplementary rations to uphold the milk yield.

The following table from F. H. Garner illustrates this point. The table also illustrates that under these grazing conditions the supplement fed during the early part of the season need not be high in protein.

TABLE 126. SUMMER RATIONS FOR COWS ON GRASS

Period	Grass Provided	Carbohydrate mixture lb.	Balanced concentrates lb.
14 April–31 May	Maintenance + 3 galls. milk		—
1–30 June ...	Maintenance + 1½ galls. milk	6	4
1–31 July ...	Maintenance	—	14
1–31 August ...	Maintenance, provided additional green food is fed	—	14
1–30 September	Maintenance, provided green food is fed ...	—	14
1 October ...	Exercise ground only. Winter feeding commences.		

Food Supplies—It is most important that farmers should produce on their own farms a considerable part of the total foods they require for their stock. It is especially important to attempt to supplement the meagre supplies of protein that can be bought by growing protein on the farm. The following tables set out the contribution from various crops towards the energy and protein requirements of farm livestock.

TABLE 127
PRODUCTION CAPACITY OF VARIOUS CROPS
(E. T. Halnan and F. H. Garner.)

Crop	Yield tons per acre	S.E. lb.	P.E. lb.
Good hay	2½	2,688	437
Poor hay	2½	1,232	162
Silage (mixture)	12	3,494	538
Kale	20	4,032	582
Mangolds	30	4,704	269
Beans	1⅓	1,922	582
Oats	1⅛	1,680	224
Maize green	20	4,077	358
Dried grass	3	3,474	625
Silage (good)	8	2,150	358

TABLE 128. PRODUCTION CAPACITY OF VARIOUS CROPS
(H. I. Moore.)

Crop	Yield per acre	Yield of crude protein per acre
		lb.
Dried grass	3 tons	1,112
Kale	30 tons	1,075
Ley grazed	12 tons	994
Lucerne cuts	12 tons	860
Silage mixture	10 tons	831
Beans	30 cwt.	748
Peas	25 cwt.	663
Seeds and hay	40 cwt.	536
Aftermath silage	4 tons	
Meadow hay	30 cwt.	490
Aftermath silage	3 tons	
Linseed	20 cwt.	434

Cropping for Stock Food—On many farms more use coul be made of catch crops and forage crops. The following tabl summarises the necessary information :—

TABLE 129. Catch and Forage Crops (H. I. Moore).

WHEN TO SOW	WHAT TO SOW	WHEN READY
February	Rye and peas	June.
March	Italian ryegrass (10 lb. per acre)	Autumn to Spring.
	Trefoil (2 lb. per acre)	
	Cabbages	November–March.
	Kale	September–Decembe
	Cereal-Legume mixture	July–August.
April	Italian ryegrass-trefoil	Autumn to spring.
	Cabbages	November–March.
	Kale	October–January.
	Cereal–legume mixtures	July–August.
	Lucerne	Autumn onwards.
	Rape	6 weeks' time.
	Lupins	July onwards
	Mustard	6–8 weeks' time
May	Turnips	September.
	Maize	August–September.
	Buckwheat	12–14 weeks' time.
	Cabbage	Early spring.
	Buckwheat, peas and rape	12 weeks' time.
June	Cabbage	Early spring.
	Maize	September.
	Mustard and rape	6–8 weeks' time.
	Turnips	September.
July	Turnips	September–October.
	Mustard and rape	6 weeks' time.
	Crimson clover	September–June.
	Cabbage	Spring and summer.
	Rape, kale	Spring.
August	Italian ryegrass-trefoil	October–spring.
	Turnips	October.
	Rape and mustard	6–8 weeks after sowi
	Crimson clover	May–June.
	Cabbage	Late summer.
September	Italian ryegrass-trefoil	Spring.
	Crimson clover	May–June.
	Rye	May.
	Rye and winter vetches	May.
October	Winter barley	May–June.
November	Wheat and winter vetches	July.

Grazing Requirements of Stock.—In Table 130, page 384 different classes of stock at varying levels of production are shown in relation to the pasture units they require. Thus a cow weighing 10½ cwt. yielding an average of 2 gallons of milk per day requires daily 12 lb. starch equivalent which during a season of six months is approximately 1 ton of S.E. or 1 pasture unit. That is it requires 1 acre of the type of pasture shown below, as valued at 1 pasture unit per acre.

A pasture of 1 unit per acre is one capable of producing approximately 8 tons of fresh grass per season yielding nearly 1 ton of starch equivalent. Pastures yielding more or less than this are valued at more or less than 1 unit per acre. These valuations are shown below:—

Finest permanent fattening pastures and first year seeds pastures on best arable land = 1¼ units per acre.

First-class permanent pastures and first year seeds pastures on average arable land = 1 unit per acre.

Good permanent pastures and pastures of second and subsequent years on average arable land = two-thirds unit per acre.

Poorer low land and average semi-upland pastures = ½-unit per acre.

Hill pastures = one-fifth to one-third unit per acre.

Mountain grazings = one-fortieth to one-fifth units per acre.

In attempting to assess the stock carrying capacity of grassland no hard and fast rule can be made.

TABLE 130
PASTURE REQUIREMENTS OF STOCK
(J. A. S. Watson and J. A. More.)

Cattle	Live weight cwt.	Total daily ration (starch equivalent) lb.	Concs. ration (S.E.)	Grass ration (S.E.)	Pastur units per heac
Milch cows yielding 2 gall. per day	10½	12	—	12	1
Fattening bullocks ...	10½	13½	1½	12	1
Dairy and Store stock—					
6–12 months ...	4	6	—	6	½
12–18 months ...	6	7½	—	7½	3/5
18–24 months ...	8	9	—	9	¾
Cattle for early fattening—					
6–12 months ...	5	7½	—	7½	3/5
12–18 months ...	7	8½	—	8½	⅔
18–24 months ...	9	10	—	10	5/6
Sheep					
Breeding ewes, large, with twin fattening lambs	lb. 200	5	1	4	⅓
Breeding ewes, large, with single fattening lambs	—	3¾	¾	3	¼
Breeding ewes, large, with twin store lambs	—	4½	½	4	⅓
Breeding ewes, large, with single store lambs	—	3¼	¼	3	¼
Breeding ewes, small, twin lambs	120	3¾	¾	3	¼
Breeding ewes, small, with single lambs ...	—	3	¼	2¾	5
Yearling sheep—					
Fattening	100	1 3/5	2/5	1 1/5	1/1
Store	100	1 3/5	—	1 1/5	1/1
Fattening weaned lambs	80	1½	3/10	1 1/5	1/1
Horses					
Draft mare (and foal) ...	1,500	15	—	15	
Yearlings	700	8	—	8	
Two-year-olds	1,000	10	—	10	5/

From these tables an approximation can be made of pasture required by different groups of stock.

In making such calculation it may be assumed that g pasture land if intensively managed by rotational grazing regular and adequate manuring will be capable of carrying more stock than is indicated by the above table.

Linton and Williamson give the following figures as guides for estimating the stock carrying capacity of grassland.

1 calf = 2 sheep.
1 heifer = 4–5 sheep.
1 store bullock = 4 or 5 sheep.
1 cow = 6 sheep.
1 fattening bullock = 6 sheep.
1 horse = 6 sheep.

First year grass on best land and the best permanent pasture = 7–8 sheep per acre.
First class permanent pastures = 6 sheep per acre.
Average pastures = 4 or 5 sheep per acre.
Poorish pastures = 3 sheep per acre.
Hill and mountain grazing = ½–1 sheep per acre.

TABLE 131 WEIGHT OF SOME FOODS PER BUSHEL.

Salt ... ...
Lentils ... ...
Maize .. ..
Dari ... ...
Millet ... ...
Potatoes ... ...
Wheat flour ... ...
Wheat meal ... ...
Linseed ... ...
Decorticated cotton cake meal ... ...
Bean meal ... ...
Decorticated cotton cake (broken) ... ...
Gluten meal (Paisley) ... ...
Maize meal ... ...
Mangolds ... ...
Swedes ... ...
Turnips ... ...
Linseed cake (broken) ... ...
Barley (ground)... ... .
Brewers' grains (wet) ... ...
Malt ... ...
Carrots ... ...
Oatmeal ... ...
Undecorticated cotton cake (broken) ... ...
Beans and oats (ground) ... ...
Middlings ... ...
Rye meal ... ...
Oats (ground) ... ...
Mixed chop (wetted) .. . .
Brewers' grain (desiccated) ... ...
Bran ... ...
Malt Culms ... ...
Hay (chaffed) ... .
Oat straw (chaffed) ... ...
Oat chaff ... ...

FARM POULTRY

Poultry are economic converters of home grown foods into table eggs and birds and are considered seriously as part of most farms' general business.

The old time "barn-yard" hens had no special housing or feeding and the manure was mostly wasted round the steadings, but they provided for farm house needs and domestic pin money. Modern well-maintained farm poultry units can be one of the main profit earning enterprises on the farm and contribute to land management, soil fertility and pest destruction in addition.

Compared with specialist poultry farms where every outgoing must be charged directly against the birds, general farms offer many factors that the poultry can share. Part time supervision and labour, cheaper foods, transport, rent, grazing and other incidentals give the birds certain financial advantages. Maintenance costs are relatively low and health standards high and given reasonable production profit should be assured.

Commercial egg production is the chief poultry objective, with table birds coming from cockerels surplus to pullet rearing and older hens as boilers as secondary sources of income. Breeding is largely left to specialists since it demands particular skill and more time than can be spared on most farms. By purchasing day-old pullets from hatcheries or growing birds (to avoid heated appliance rearing) good laying strains can be obtained and the replacements will be birds hatched at the best times of the year to be profitable.

Clean land contributes materially to poultry health and profit. High mortality in the 1930's was largely due to heavy concentrations of birds kept continuously on limited areas. The consequence was a building up of parasitic infestations and harmful organisms that undermined stamina making the stock vulnerable to various infections and epidemics, e.g., fowl paralysis.

By taking the poultry flocks round the farm both benefit, the droppings are more widely distributed and the risk of infection lessened. Ploughing after a period of poultry occupation buries the manure, giving a gradually available supply of organic nitrogen, phosphorus and potash for the following crop thus building up fertility. In this way the manure is utilised by cropping and better quality grass is produced for grazing or for carrying poultry again after some years.

Poultry are constant grazers where the herbage is fine, short and actively growing, and the grass intake reduces other food requirements. On range they find animal, vegetable and mineral additions to the hand feeding, which lessen costs and promote health. The birds' scratching activity is useful—especially on old pastures—in tearing out mat and mosses, so allowing regrowth of the finer grasses. Insect pests are also kept down, notably wireworms.

Poultry can be kept on the land in mobile field houses (slatted or solid floors) holding 50 to 60 birds and moved in lines over the fields. Fold units (20 to 25 birds), controlling the birds within their runs are moved to constant fresh grass patches daily and require no night shutting. Sectional semi-intensive houses for up to 200 birds can be located about the grass land, and after a year or two dismantled, removed and re-erected on a fresh field.

Feeding can be half home grown grain—whole wheat, oats and barley in order of preference, or mixed—and half a laying meal mixture containing up to 15 per cent. protein (at least 5 per cent. animal protein) or whole grain and compounded balancer pellets. Water is usually carted, house moving and cleaning being undertaken at the same time. Water is given at the morning feed and eggs are collected after the evening feed. Steamed potatoes are used mixed with meals, and kales, cabbages and roots are appreciated when grass is lacking.

One man can look after up to 1,500 birds kept in this way, provided it is his only work, and he is given help with cleaning and transport. Seasonal work, such as rearing, must be done independently. It is important to have fully man-sized units or to limit the poultry when suitably housed and conveniently placed to just what can be looked after by part-time family labour.

If run at the same time or alternated with other grazing stock on permanent grass land, up to 150 birds to the acre are sufficient, but up to 250 per acre can be put on fields devoted entirely to poultry and ploughed after say two years. A thousand adult birds will produce some 30 tons of rich manure yearly.

REARING—Since it is profitable to replace most of the laying flock each year, chick rearing needs special attention. The day-olds can be started in small outdoor heated brooders and go out on to good short grass swards that have been rested for 12 months. Chicks should not have access to ground used at any time by adult birds. The food can be cut or rolled farm cereals and rearing meal (later pellets) with about 15 per cent protein content, also powdered or liquid milk if available. White fish meal, with its high mineral content, is the best animal protein for poultry at all ages. Daily moves to fresh grass patches and control to prevent return to used sites is an important factor in health and growth.

GROWING—After six to eight weeks the chicks can go to arks, folds or colony houses, standing, if possible, on a new ley, but in any case not on ground recently used by adult stock. The rule should be new birds to new land and no mixing of young and old. At three to four months of age they can be settled down in their permanent laying quarters.

INTENSIVE METHODS—Even where there is wide outdoor scope it is sometimes economic to keep the poultry intensively near to hand, carting their manure to the land and feeding the crops so fertilised to the birds in batteries, semi-intensive houses or yards. By conveniently massing the layers, labour in feeding, watering, egg collecting and cleaning is saved, the man-unit being sometimes up to double that under outdoor conditions.

BATTERIES—Single laying cages with wire floors in which each bird has its own food and water, are arranged in groups, three tiers high in large fixed buildings suitably lighted and ventilated. The cost of cages, housing, lighting and in some cases mechanical cleaning and feeding is higher than with any other method, but so are the returns, especially in winter eggs. Cod liver oil at 1 to 2 per cent. must be used continuously in the food.

INTENSIVE HOUSES—Large, glass fronted houses, with perches over pits or boards, and deep litter floors, accommodate one bird per 3 sq. ft. of floor space intensively. Very small outdoor runs, if any, are used, or wire floor sun parlours. High winter production can be maintained, and dry mash or pellets are generally fed from hoppers always before the birds and grain in the scratching litter.

HEN YARDS—A combination of perches over pits for droppings and laying places under cover with deeply strawed open yards, provide cheap laying quarters where existing buildings can be adapted. Laying meal or pellets is fed in troughs under the covered section and grain in the strawed yard. This gives exercise and breaks up the litter to which more straw is constantly added.

In none of these methods do the birds benefit from grazing and other fresh natural food, so the feeding must contain dried grass meal, vitamins and mineral mixtures in compensation.

INTENSIVE REARING—First stage indoor chick rearing is useful for winter work and where large numbers are reared over a long season. Long brooder houses are subdivided for unit numbers and successive hatches, each compartment with its own hover, being heated by oil, water, or electricity and approached from the attendant's gangway. The chicks are on litter and possibly allowed out on wired floor sun balconies. but have no access to the grass or ground. Tier or battery brooding is another form of intensive first stage rearing, the chicks being on small mesh wire floors, with the sleeping compartment heated above or below and the run portion fitted with outside feeders and drinkers accessible through barred grids. At about three weeks the chicks are usually moved into cooler cages and to floor brooding at about five weeks old Feeding has to be specially designed to permit this intensive rearing, and must include cod liver oil and all vegetable, vitamin grit and mineral needs.

It is generally agreed that for all subsequent purposes. the growing period from about eight weeks to approaching maturity should be spent outside on grass, in fold units or in large pens.

BREEDS—In pure breeds Rhode Island Reds are the best laying and general purpose farm birds ; Leghorns lay well if given protection ; Light Sussex combine excellent table qualities with fair laying. As crosses Rhode Island Red (males × Light Sussex (females) give a sex-linked cross that lay excellently outside or in batteries and make fine table birds Leghorn × Rhodes (hand sexing necessary) are high clas layers and Brown Leghorns × Light Sussex (sex linked) make a good small table bird and lay well. For commercial egg production on general farms where no breeding is undertaken crosses, bought as day-olds, are probably the safest investment Before commencing any specialised poultry branch—e.g. accredited breeding, commercial hatching-egg production rearing pullets in numbers for sale, or continuous table chicken rearing—specialist advice should be sought from the Count Poultry Adviser.

DUCKS—A few ducks for both table and eggs can find place on most farms, but large flocks are too costly to feed unless they find much free food ranging widely over suitabl moist land and water. Khaki Campbells combine laying and table qualities ; Runners are layers, and Aylesburys the finest table birds for quick growth and flesh quality. Production o first class ten week ducklings is highly skilled work.

GEESE—A breeding trio is easy to maintain and profitabl there being goslings for sale and a limited number of table bird Flocks of geese must have suitable short grass range—such a common land—as they can then live most of the year by grazing Embdens, Toulouse and the cross between them are the bes large breeds, with Roman and Chinese as lighter birds and better layers.

TURKEYS—All the year production of turkeys kept both outside and intensively is growing. They require dry conditions and can be reared exactly like ordinary chicks. Good grazing is important—or fresh greens taken to them intensively—and constant fresh land to avoid "blackhead." They must not come into contact with any other poultry. Light land cereal farms offer good conditions for turkeys which can find much free food after harvest. American Mammoth Bronze make the heaviest birds, while Norfolk Blacks and Austrian Whites are smaller breeds making popular birds for small families. American Broad Breasted Bronze are gaining popularity.

ANIMAL HEALTH

Certain contagious diseases must be reported immediately to the police, and the diseased or suspected animal, or carcass, kept isolated pending the visit of the Veterinary Inspector who gives instructions as to what course to pursue. These Notifiable or Scheduled diseases are: Foot and mouth disease; swine fever; fowl pest or Newcastle disease; anthrax; sheep scab; parasitic mange of horses, mules and donkeys; tuberculosis; fowl cholera; cattle plague; contagious pleuropneumonia of cattle; sheep-pox; epizootic-lymphangitis; glanders and farcy; rabies. It is the duty of any veterinary surgeon coming across any of the above during farm visits to report the matter at once to the appropriate authority. Quite apart from any penalty for failing to report, it is in the farmer's or stock owner's own interest to do so, as timely and expert intervention may save the lives of valuable animals, or prevent the disease from becoming widespread.

Prevention of Disease

Quarantine—To prevent the importation of disease to a farm, all fresh comers, whether they be animals or birds, should be kept isolated for 30 days before being allowed to mix with those already on the place.

Inoculation—On farms known to be infected, as may be the case with swine erysipelas, blackleg, lamb dysentery, etc., animals may be protected by inoculation with the appropriate vaccine, or given a temporary immunity by the injection of the anti-serum.

Hygiene—The cleanliness and disinfection of the premises and equipment, and the disposal of the manure, so that it cannot contaminate the water supply or foodstuffs, plays a major part in the prevention and spread of all infectious and contagious diseases. Rats are a frequent source of disease, and money and time spent in their destruction is well spent.

Swine Fever—This is one of the Scheduled Diseases. Even a suspicion of its presence must be reported to the police at once, there being a penalty for failing to do so.

Cause—A filter passing virus.

Incubation period—The interval between infection and the appearance of symptoms, is on the average 5–15 days.

Symptoms—These at first may be rather indefinite, and may be masked by secondary bacterial infections. Suspicious signs are lack of appetite, shivering, reluctance to move and a staggering gait when forced to do so, burying and hiding in the litter, high fever, 104°–107° F (normal temperature 102·6°) a purplish discoloration of the skin of ears, belly and hock scouring, maybe vomiting, increased thirst, coughing, difficul breathing, nasal discharge, and other signs of inflammation o the lungs.

The disease should be suspected when a number of youn pigs become sick and die with some or all of the above symptoms and especially so if the trouble starts within a few days of th purchase of fresh pigs, or those returned to the farm from market, a show, or the boar, or after a visit from the gelder.

Prevention—Quarantine of new-comers for 30 days ; inoculation of healthy pigs with the Crystal violet vaccine.

Treatment—The injection of both ill pigs and their in-contac with swine fever anti-serum. This, however, must be don at the very earliest possible moment and hence the necessit to report the trouble at once and get help from the Ministry

Anthrax—This is one of the Scheduled Diseases, which mus be reported to the police, under a penalty for failing to do sc

Cause—The Bacillus anthracis.

Incubation period—The interval between infection and th appearance of the symptoms may be 12–24 hours or more.

Animals susceptible—The human being (malignant pustul and wool-sorters' disease) ; all animals and birds althoug Algerian sheep are said to be immune.

How infection occurs—Infection occurs from the taking o food which has been contaminated by the spores of the bacillu by inhalation of the spores contained in dust, etc., by th blood of a diseased animal contamination, a wound of th skin, the devouring of an anthrax carcass by pigs, dogs, bird etc., and possibly by inoculation by biting or blood-suckin insects.

Symptoms—In the peracute form, animals may be foun dead without having shown any symptoms, but usually whe an animal becomes affected, it separates itself from the her refuses all food and drink and looks the picture of misery wit hanging head and staring coat ; the temperature is raised, an shivering fits occur ; swellings may be seen around the throa mostly, however, in horses and pigs ; a trickle of blood may b seen coming from the natural openings of the body. Th duration of the disease is seldom more than 48 hours.

Prevention—While it may not be possible to prevent a outbreak of anthrax, and anthrax is not a disease so easi recognised as it might appear, it is possible to prevent its sprea by taking the following precautions :—Suspect the disease i any animal found dead ; do not move or touch the body bu put a fence round it and remove all other animals from the vicinity ; do not kill a sick animal or move it but isolate it where it stands ; always remember that the blood of an animal suffering from anthrax swarms with the germs which immediately commence to form spores when outside the body. Isolate the in-contacts of the suspected animals in a separate place. Any blood which may have been spilled or has issued from an infected animal should be covered with a strong solution of an approved disinfectant.

Treatment—When a diagnosis can be made early enough, massive doses of penicillin, injected every 3–4 hours for 3–4 days, may save life and may be combined with injections of the antiserum, which latter may be used to give immediate protection to the in-contacts of the diseased subjects. On farms where the disease appears year after year, animals may be given protection against it by inoculation.

Foot and Mouth Disease—This is a Scheduled Disease and must be reported to the police.

Cause—It is a contagious and eruptive fever due to a specific filterable virus of which there are four types or variants.

Incubation period—12 hours to 12 days.

Animals susceptible—All animals may suffer from this disease but cattle, sheep and pigs are especially liable. Human beings may also become infected.

Symptoms—In cattle, sheep and pigs the disease begins suddenly and may spread rapidly. The first symptoms are usually lameness, smacking of the lips, and dripping of saliva from the mouth. In cattle vesicles appear on the inside of the upper lip and on the tongue, between the toes and on the teats, but in the pig they may also appear on the body. The milk of affected cows may spread the disease to other animals, including the human. Condition is rapidly lost, and the milk yield falls considerably. Very young calves may die from inflammation of the bowel without showing any of the eruptions.

Treatment—Treatment is not permitted in this country and the authorities who take over the control of the disease give full instructions and orders regarding methods for preventing spread of the disease.

Parasitic Mange in Horses, Mules and Asses—This is a Scheduled Disease of which even the suspicion must be reported to the police at the earliest possible moment.

Cause—Parasitic Mange is a contagious skin disease caused by parasitic mites which belong to the family " acaridae." The mange mites are exceedingly small and usually only visible through a handglass or microscope. Three varieties of mange occur in this country, namely, the psoroptic, sarcoptic, and symbiotic (the latter not reportable). The sarcoptic form is the most serious as the mites burrow into the skin making small tunnels in which their eggs are laid. The spread from the first parts attacked is relatively slow while in the psoroptic form in which the mites live on the surface of the body the disease spreads rapidly, in neglected cases all over the body. In the symbiotic form the trouble is usually confined to the legs from the hooves upwards to just above the hocks, or knees, as the case may be, and only very exceptionally invades other parts of the body.

Symptoms—In all three forms the most prominent symptom is irritation, the animals rubbing themselves against anything within reach and in the symbiotic form the most prominent is stamping with the affected leg or rubbing one leg against the other. The irritation increases during the night when in a warm stable. The hair over the affected parts may stand erect and bare patches of the skin are seen due to the hair having fallen out or been rubbed off. The skin may show little pimples rather like flea bites from which later a discharge exudes and small scabs form. In advanced cases the skin becomes dry and hard and corrugated into folds and later the skin may crack and deep fissures form. Owing to the intense irritation, condition is rapidly lost and the subject may even die from intense debility and exhaustion. The trouble is spread by direct or indirect contact. In fact, anything that has been in contact with a mangy animal may be a vector of infection unless it has been thoroughly cleaned and disinfected.

Treatment—With the exception of symbiotic mange the whole of the body must be included in whatever dressing is selected, and the animal clipped close all over before it is applied. The dressings may be applied either by dipping or by spray and one of the most successful of the older " dips " is the one known as " lime and sulphur." Latterly, mange has been treated successfully by two or three thorough sprayings at 10-day intervals with a ·25 watery suspension of benzene-hexachloride.

The authorities which take charge of the outbreak will give instructions as to isolation and disinfection of premises and equipment.

Sheep Scab—This is a Scheduled Disease which must be reported under penalty for failing to do so.

Cause—A contagious disease caused by parasitic mites Occurs in two forms—psoroptic scab, due to the psoropte communis being the most common, and sarcoptic scab, o mange, due to the sarcoptes of the var. Ovis, but this rarel occurs.

Incubation period—Varies from three weeks to six months.

Symptoms—The symptoms are restlessness, biting at the affected parts, rubbing against boxes, fences, hurdles, etc., or other sheep in an attempt to relieve irritation caused by the mites breaking the skin. Constant biting and rubbing causes injury to the skin with the formation of "crusts" or scabs under which the parasites and their ova may be found. The wool is shed, the fleece becomes broken and matted together giving the animal a ragged appearance. With the aid of a magnifying glass parasites may be seen moving about if a scraping is taken from the diseased patches and warmed in the sun.

In the sarcoptic form the head and ears are mostly affected, the irritation being more intense and crust and scab formation greater.

Treatment—The treatment consists of dipping in one or other of the dips approved of by the Ministry of which there are several, some poisonous and others not. The other advantages of dipping are that it kills keds and lice and probably ticks which are all detrimental to the general health and well-being of the sheep.

Tuberculosis—This is a Scheduled Disease, of which even the suspicion must be reported to the police and the suspected animal must be isolated immediately.

Cause—Tuberculosis is a contagious disease caused by mycobacterium tuberculosis. It affects man, and many different species of animals and birds. It may be spread by milk, manure and coughed up sputum (droplet infection) of the infected animals.

Incubation period—Very variable.

Symptoms—The symptoms are not characteristic, but in advanced cases there may be emaciation with a chronic cough, or persistent scouring. In the case of tuberculosis of the udder, which usually attacks one of the hindquarters, a hard swelling of slow but progressing growth is to be felt which is painless on pressure. The milk from the affected quarter may at first appear to be quite normal but later becomes thin and watery. Microscopic examination of the milk from the diseased quarter shows the presence of the Tuberculosis bacilli. The only certain method of determining the existence of the disease is by the means of the tuberculin test.

Sheep Pox—This is a Scheduled Disease which must be reported to the police.

Cause—A contagious eruptive fever caused by a specific filterable virus. Sheep are the only animals liable to contract this disease which has never appeared in this country other than by the importation of diseased living animals. Orders prohibit the landing in Great Britain of sheep from countries in which sheep pox exists. The virus might be imported.

Symptoms—Lambs are mostly affected and the chief symptoms are fever, intoxication and paralysis with an eruption of red spots on the membranes of the eyes and nose and all the hairless parts of the skin. It may end fatally in a few days.

In older sheep the temperature is high, there is a lack of appetite and eruptions appear as in the case of lambs, but it may also appear on the body covered by wool. It occurs firstly as small pimples which grow to the size of a sixpenny piece or larger, and the skin around the eruptions is reddened and inflamed. A yellowish discharge oozes from the pimples and dries as yellow crusts on the surface. Abortion is common in pregnant ewes.

Cattle Plague—This is a Scheduled Disease, but at present does not exist in this country.

Cause—A contagious and eruptive fever due to a specific filterable virus.

Animals affected—Bovines, rarely sheep, camels, certai wild ruminants and occasionally swine.

Incubation period—4–5 days with extreme periods fro 3–9 days.

Symptoms—High fever; the animal refuses food; is du and the coat is staring. Shivering fits occur and the breathin is quick. Watery or mucous discharge flows from the eye and nostrils, maybe blood-stained. Milk secretion is diminishe or arrested. The membrane of the nostrils is congested, an an eruption like grains of bran appears at the lower part Eruption is often followed by ulceration which may appear i the nostrils, inside the lips, and on the tongue. Constipatio at first, later diarrhoea, foul smelling and often tinged wit blood. The animal wastes away rapidly and usually dies i from six to ten days. In countries in which it is prevalen susceptible animals are protected by inoculation.

Contagious Bovine Pleuro-Pneumonia—This does not exist i this country at the present time, but nevertheless it is a Schedule Disease which must be reported to the police. The last ca recorded was in 1898. It, however, exists in Russia and Spai in Asia and in several parts of Africa.

Cause—It is a contagious disease of cattle of an acute, su acute and chronic nature, and is a peculiar form of pneumon and pleurisy. The cause is a specific filterable virus.

Animals susceptible—Cattle, buffaloes, reindeer, yaks ar bison are susceptible. Other animals, including man, a immune.

Incubation period—6-16 days.

Symptoms—Rise of temperature to 103°–104° F. followed by signs of general illness, dull coat, debility, loss of appetite, cessation of rumination, and falling off of the milk yield. A short, dry, painful cough, excited by movement, change of temperature, drinking of cold water, etc. Later the cough becomes more severe, accompanied by a discharge of mucous. Respirations are short and catchy and increased in number. Expiration is accompanied by a double lift of the muscles of the abdomen. The subject stands with elbows turned out and grunts if struck on the chest and shrinks on pressure over the ribs.

As the disease progresses the animal becomes weak and emaciated ; the belly is tucked up ; the fever increases and the heart beats weaken. The usual course of the disease is two to three weeks. Animals may die very quickly or after a protracted illness.

Rabies—This is a Scheduled Disease, but suspected animals should not be killed but kept in a safe place where no harm to others is possible.

Cause—An inoculable disease caused by a virus.

Animals affected—All animals, including the human, if inoculated with the virus. It is chiefly by the dog that the disease is spread but it may also occur among cats.

Symptoms—In the early stages maniacal symptoms, later paralysis. The dog is restless, hides or wanders from home. It may snap at persons, other animals, or anything that gets in the way. Saliva drips from the mouth ; depraved appetite ; alteration in the voice ; later the jaw drops from paralysis ; the limbs become paralysed ; the eyes may squint.

Epizootic Lymphangitis—This is also a Scheduled Disease.

Cause—A contagious and eruptive disease caused by the Cryptococcus farciminosus.

Animals affected—Horses and mules, the ox but seldom.

Symptoms—The eruption appears on the legs, the neck, the head, and any part of the body. The ulcers may not appear for months after a wound which has been infected by the organisms has healed. The lymph vessels in the skin appear cordlike and small nodules, the size of a hazelnut, appear on their course. Later the nodules suppurate and discharge thick, yellowish pus. Ulcers may also appear inside the nostrils. Lymphatic glands in connection with the lymphatics, become hard and swollen. The pus from the nodules contain the cryptococci. The disease is usually incurable.

Glanders and Farcy—These are the same disease (a Scheduled one) and caused by the Bacillus Mallei. Farcy is located on the surface of the limbs and body, while in Glanders the principal signs are seen in the nostrils, sub-maxillary glands and lungs.

Animals affected—Principally the horse tribe, but man, dogs, cats and wild carnivorae may also be infected. The ox, sheep, goats and pigs are immune for all practical purposes.

Symptoms—There may be none except a slight unthriftiness (occult) in Glanders, and this can only be diagnosed by the Mallein Test. In a clinical case there is discharge from one or both nostrils ; ulcers are seen inside the nasal cavities and on the nasal septum. Glands under the jaw are enlarged and indurated. Severe and acute cases show a rise of temperature and there may be signs of respiratory disease.

In Farcy, one or more limbs become swollen, the lymph vessels prominent on the inside of the limb ; nodules appear along the course of the vessels ; the nodules burst and become ulcers which discharge a thick fluid of oily appearance. Healing of the ulcers only temporary. Farcy may also affect the skin of the neck and body. There is no treatment.

Fowl Cholera—A Scheduled Disease which must be reported to the Authorities as soon as suspected.

Cause—An acute contagious septicaemic disease affecting domesticated birds which is accompanied by a high temperature and causes heavy mortality. The cause is a bacillus of the Pasteurella group of germs which may be found in the blood of affected birds.

Symptoms—In the peracute form the bird may die suddenly without showing any previous signs of illness. In the acute form mopiness, open feathers, disinclination to move, increased thirst, appetite diminished or suspended. There may be a mucous discharge from the mouth. The droppings may be greenish and soft, or brownish red covered with mucous. The urates are yellow in colour which should be a warning sign Death usually occurs within three days. A chronic form may appear towards the end of an outbreak, the birds being dull, mopey, and scour. There may be lameness and much wasting. The wattles may be oedematous. Birds may be protected by inoculation.

Newcastle Disease, Fowl Pest—A Scheduled Disease which must be reported to the Authorities.

Cause—A filterable virus which cannot be found in the blood as in the case of fowl cholera, but can be detected by laboratory methods.

Incubation period—Ranges from 4–11 days with an average of 6–7. The course of the disease is extremely rapid.

Symptoms—The sudden drop in the egg yield of a flock in full production frequently heralds the occurrence of an outbreak, and in some cases birds are found dead without any apparent cause. The usual symptoms are, however, loss of appetite, profuse yellow diarrhoea, laboured breathing and coughing accompanied by a " gurgle," sleepiness or even stupor may follow with a darkening of the head and comb. There may be weakness of the legs, staggering gait, with a mucous discharge from the nostrils and mouth. A characteristic sign is a bunched up and open feathered condition of the bird, a tendency to hide in a corner or in deep litter.

Treatment—There is no treatment, but birds may be protected by inoculation.

COMMON DISEASES OF THE COW

Tuberculosis—See Scheduled Diseases.

Contagious Abortion (Brucillosis)—A contagious disease resulting in the premature birth of the calf, usually at the seventh or eighth month, although abortions may occur earlier.

Cause—Bacillus of Bang, or bacillus abortis, or the brucella abortis as latterly named.

Method of spread—Chiefly by discharges from infected animals, whether they have aborted or not, contaminating the soil, food or drinking water. Infection may also occur from dirty hands, unsterilised calving ropes, instruments, etc., and, very occasionally, by the bull.

Symptoms—The calf may be born dead, or alive, and die shortly after birth, or survive and spread the disease unless kept isolated. Calving is usually easy; the afterbirth is frequently retained. The cow continues to discharge for about a month.

Prevention—Aborted animals should be kept in an easily disinfected place during the whole period of their discharge and must *not* go to the bull again until perfectly clean and two months, at least, have elapsed since abortion. All empty cows and heifers and those which become empty later on may be inoculated with S. 19 Vaccine, and as a long-term policy, heifer calves should be inoculated at from 4–6 months of age. Fresh purchases should be isolated until they have either passed a blood test or have been given an injection of S. 19.

Mastitis, Mammitis or Garget—A contagious disease caused by a bacterial infection of the udder usually in one quarter only. Although numerous organisms have been found to give rise to this condition the term is now used to designate an infection by the streptococcus agalactia. It may occur in the acute form in which there is considerable inflammation of the affected quarter accompanied by pain and swelling and constitutional disturbance, but more frequently in the sub-acute form in which tenderness is not excessive, although the enlargement of the quarter may be considerable. In the chronic form which may occur primarily, or follow either of the above, the affected quarter gradually becomes larger and firmer t the touch, but insensitive to pressure. In extreme cases th form may give a lop-sided appearance to the udder.

The milk from an affected quarter may be blood-tinge contain clots of casein, shreds of mucous, and even pus. other cases the milk is watery containing many clots a shreds. In the chronic form the milk may not show a distinctive changes, but its secretion becomes gradually le and less and the quarter becomes quite inactive. In all cas the causative germs may be isolated from the milk in t aboratory.

Mode of spread—Infection for the most part enters by t teat canal, and infection is favoured by wounds or chaps the teat ends. It may be spread by the hands of the milk by milking machines, by the teats coming into contact w infected bedding, and possibly by flies.

Prevention—The prevention of infection is greatly handicapp by the fact that infected cows may pass out the causative ger in their milk days before there is anything to show they a infected. Affected animals should be isolated immediat in an easily disinfected place off the pastures, given a separ attendant when possible or attended to and milked by ha last of all. Everything drawn from an infected quarter shou be received into a pail containing a strong disinfectant. T milk from the remaining quarters should be sterilised boiling before being used for any purpose. A high stand of hygiene must be maintained in the cow-stalls, particu attention being paid to the sterilisation of milking machin udder cloths, etc., and the cleanliness of the milkers' hands

Treatment—The treatment which has proved most uniform successful is the injection of massive doses of penicillin up three or four occasions, and it has been found desirable inject all four quarters whether they show signs of the dise or not, and, furthermore, to forestall the spread of infect from non-clinical cases, as mentioned above, it is recommen that every cow in the herd receive injections of penici The initial expense of this may appear to be high but as a l term policy this method has proved to be most economi Where there is much swelling and tenderness of the affec quarter hot fomentations give relief. If there is an excess rise of temperature, as in acute cases, a dose of Epsom s may be administered. Non-response to penicillin medica means that the infection is due to a non-penicillin sensi germ or group of germs, and the treatment of such cases depe upon the bacteriological findings.

Summer Mastitis—Summer mastitis is a disease affect more particularly dry cows and heifers while at grass dur the late summer and autumn months, namely, during the worst of the "fly" season, whereas the ordinary form of mastitis is more particularly a disease of lactating cows.

Cause—The cause is the bacillus pyogenes as chief invader, but, as in other forms of mastitis, there may be other secondary invaders. Infection takes place via the teat canal and is favoured by wounds on the extremity of the teats and by the exudation of a drop of fluid on the teat-ends which not only attracts flies but forms a suitable medium for bacterial growth. Infection may also occur when cows wade into stagnant ponds or pools to drink, or from contact with discharges from a diseased udder. The infected quarter becomes inflamed and considerable pus formation occurs, the usual result being the loss of the quarter, or, in severe cases, even the death of the subject.

Treatment—Treatment is usually unsatisfactory and the result very variable; some cases respond to penicillin or the infusion of antiseptics into the infected quarter; others fail to respond. In some cases it may be prevented by the injection of a toxoid which has also been used in treatment, but here again results are very inconsistent.

The trouble, however, may be prevented to a certain extent by making sure that no fluid is left in the udder of presumably dry cows or present in the udders of "bulling" heifers; that the teats are kept clean; any little wound or other sore disinfected as soon as noticed, and, in many cases, by sealing the teats with collodion or even a dab of tar. Affected animals should, of course, be taken from the pastures at once, and kept isolated in an easily disinfected place.

Johne's Disease—Johne's disease, or para-tuberculosis or pseudo-tuberculosis as it has been variously called, is a contagious disease resulting in a chronic inflammation of the intestines.

Incubation period is very variable from a few months to two years or over.

Cause—The cause is a bacillus of the same name, or the mycobacterium paratuberculosis.

Animals susceptible—Cattle, sheep and goats.

Mode of spread—The droppings of infected animals contaminating the soil, food, or drinking water. A disturbing feature is that infected animals may spread the disease before showing any clinical symptoms, thus making preventive measures exceedingly difficult.

Symptoms—These come on slowly by attacks of intermittent but persistent scouring which does not respond to the usual methods of treatment. This is accompanied by a gradual but progressive loss of condition, except in the case of an acute breakdown in which condition is lost very rapidly and the scouring is practically continuous. Many animals show no symptoms until something happens which lowers their resistance, such as a difficult calving; attacks of illness; poor feeding or adverse climatic conditions. All cattle which are periodically tuberculin tested and which show a constant high reaction to the Avian test should be regarded with great suspicion if the reaction suddenly becomes diminished, as this, in a very great many cases, is a premonitory sign of an impending breakdown.

Treatment—No successful treatment and suspected cases should be taken from pasture at once, isolated and disposed of as soon as such suspicion has been confirmed by the usual bacteriological methods.

Trichomaniosis—A contagious venereal disease transmitted by coitus which may result in infertility, or abortion, in the early stages of pregnancy.

Cause—The cause is the trichomonas fœtus, a microscopic parasite. It inhabits the genital tract of both males and females, and in the latter may be associated with pus-producing germs with very serious results.

Symptoms—The disease can only be diagnosed with any certainty by microscopical examination but may be suspected when a cow returns to service or aborts quite early in her pregnancy. There may be a discharge from the vagina which dries on the hairs of the external parts. In the bull a reluctance to serve a cow after having been a good worker is a suspicious sign. There may, or may not be, a discharge from the prepuce in the first stages of the infection.

Treatment—Treatment in the female gives good results as a rule when carried out by a veterinary surgeon. The value of treatment in the case of the bull is doubtful.

Prevention—All service should be suspended for at least four months and an infected bull should only be used on cow which have suffered from the disease. These should be kep apart from healthy cows and virgin heifers which should be served by a bull known to be free from the infection.

Hoven, Tympanitis of the Rumen—A condition in which the rumen becomes greatly distended by gas. If not relieved may result in the death of the subject from suffocation. It occur in an acute and chronic form. The former necessitates promp and energetic treatment to save life.

Cause—Eating some food which rapidly ferments in the rumen, e.g., rank lush clover or herbage, frosted or immature roots, or fermented foods. In the chronic form the cause ma be indigestion, a lack of tone of the digestive organs, foreig bodies, tumours, or tuberculous lymphatic glands.

Symptoms—In the acute form the rumen becomes greatly distended by gas and may bulge into the hollow of the flank on the left side. The subject may show respiratory distress. A drum-like sound is produced if the swelling is slapped with the flat of the hand. In the chronic form the subject may be bloated to a lesser degree or become so only after taking a meal.

Prevention—As a matter of practice the acute form may be prevented by giving a feed of hay before cattle are turned out on to lush pastures as this not only appeases hunger but promotes belching ; the avoidance of feeding spoiled fermented food ; frosted or immature roots. The cause in the chronic form is not so easily determined, especially when the foods and feeding are all that they should be.

Treatment—In cases of very great distention and when suffocation appears to be imminent, the gas must be liberated without delay with the trocar and canula, but in less urgent cases 2 oz. of turpentine mixed with 1½ pints linseed oil may be given. The latest theory suggests the condition may be a form of anaphylactic shock producing paralysis of the rumen and injections of adrenalin have proved successful in some cases. The jaw movements and belching may be encouraged by the insertion into the mouth of a piece of rope fastened up over the head like a bridle. In the chronic form, apart from the avoidance of unsuitable foods, the treatment must be left to the veterinary surgeon as an operation for the removal of foreign bodies or materials may be required.

Foul in the Foot—Foul in the foot, or foot-rot is an inflammation of the foot between the claws or toes caused by bacterial infection by organisms which may be found in the soil, in filth and dirt.

Causes—Overgrowth of the claws, dirt, foreign bodies or stones becoming wedged between the claws and wounding the skin. It is most frequently seen in the hind feet but all four feet may become infected.

Symptoms—Lameness, heat and swelling about the hoof and of the soft parts between the claws. In neglected cases abscesses may form or the infection extend into the joints and tendons.

Treatment—The intravenous injection of one of the sulphonamides has been found to be a specific remedy for this disease, but, at the same time, abscesses must be lanced, decayed horn pared away, the " boil " between the claws opened up freely and the " core " expressed. The old line of treatment, which was tedious in the extreme, consisted of poulticing, soaking the foot in hot antiseptic solutions and the application of antiseptic dressings to the part. When the joints or tendons become infected amputation of the affected digit may become necessary so there should be no delay in the treatment of foul in the foot.

Lice—Cattle may become infested by hæmatopinus eurysternus which is a blood sucker or trichodected scalaris—" the little red louse "—which is a biting louse. The eggs, or nits, are fastened to the hairs.

Symptoms—Irritation, rubbing, and maybe loss of hair.

Treatment—Infected animals may be washed all over, not neglecting under the throat and the hollow of the heels, with :—

Derris Root Powder...	4 ounces.
Soap Powder	½-ounce.
Warm Water	1 gallon.

This kills lice and nits. An alternative treatment is to spray all over with a 0·25 solution of Gammexane Dispersible Powder in water. This may need to be repeated after an interval of about ten days.

Mange—Cattle have four kinds of itch or mange—chorioptic mange, caused by chorioptes symbiotes, is found chiefly at the base of the tail, sometimes on the neck. Sarcoptic mange, caused by a burrowing mite, is rare in cattle. Rarer still is demodectic mange, which is caused by a parasite which lives in the hair follicles, producing pimples which renders the hide of less value. The commonest form of mange is caused b psoroptes communis.

Treatment—Mange in cattle may be treated with a lime an sulphur sheep dip, by the gammexane watery suspension (se lice), or by a solution of potassium sulphurata, one ounce t the gallon of water. Three treatments a week apart are usuall required to effect a cure.

Ringworm—A contagious skin disease caused by a fungu of the genus trichophyton growing on the skin, the result bein a loss of hair in more or less circular patches which may occu on face, neck, back, root of tail, etc. The skin becomes scurf and scaly and in some cases heavily encrusted by scabs.

Treatment—Scabs, scales and crusts must be softened u with hot water, soap and soda, and rubbed off with a piece o sacking, burnt after use. When dry the affected areas and wide margin around may be painted with a mixture of 1 par creosote, 7 parts linseed oil, or painted with tincture of iodin or, in persistent cases, with 1 part salicylic acid, 1 part ethe 8 parts Friar's Balsam. In-contact cattle may be protected b spraying with the lime and sulphur sheep dip.

Verrucae or Warts—Warts may occur on any part of th body and give much trouble when situated on the teats. The are said to be infectious and caused by a virus. Those wit distinct " necks " can be removed by the application of a tigh ligature. Others by painting with Friar's Balsam mixture, as advised for ringworm applied every day.

Warbles—These are swellings on the back of cattle containing the maggot of the warble fly (hypoderma bovis, or H. linneata), either of which flies lay their eggs on the hairs of the legs in the vicinity of the hocks. The larvæ, which hatch out from the eggs, enter the body and make their way to the gullet from which they migrate to the back and occupy the swellings as maggots. To break the life cycle of the fly the maggot may be squeezed out in the spring, or killed by applications of the official mixture of derris root powder and water. Treatment must be given every 15 days from the first appearance of the warbles in the spring to about the end of June. Fly repellants may be sprayed on the legs, but soon lose their effectiveness and several applications may be necessary during the fly season.

Cow Pox—This is a contagious disease due to a virus closely associated with the virus of human smallpox. It appears on the teats and udder first as nodules or papules which become blisters and then pustules which burst and leave a saucer-like depressed scar or pit. The disease runs its course in spite of treatment. Secondary infections should be kept down by the application of antiseptics. Cause as little damage to the teats as possible while milking and stripping.

Milk Fever or Parturient Collapse—The latter is the better name for this condition because there is no fever at all and the term "milk fever" should really be reserved for cases of puerperal sepsis.

Cause—A drop in the level of the blood calcium due to a temporary breakdown of the endocrine nervous mechanism which controls the level of calcium in the blood. The calcium salts taken into the body with the foods are stored up in the skeleton from which they are abstracted as required to keep up the proper amount of calcium in the blood. In parturient collapse the onset of lactation makes a sudden and considerable drain on the blood calcium which, for some unexplained reason, paralyses the mechanism which should keep up the supply from the bodily reserves.

Symptoms—These usually appear within 24 hours of the birth of the calf, but may do so before parturition or at a much later date. The first stage of the trouble is usually more or less excitement varying from considerable uneasiness to violence. As the condition progresses the animal falls to the ground and becomes insensible, either lying stretched out on its side or with her head turned round to her flank. Rumination stops and neither fæces nor urine are passed. If untreated the coma becomes deeper and deeper and death eventually ensues.

Prevention—The modern means of preventing the onset of parturient collapse is to give an injection of calcium solution just before and another very shortly after calving in order to keep up the level of the blood calcium. In heavy milking cows which have already suffered an attack, the practice of "steaming up" should be avoided. Care must be taken to see that a cow has an adequate mineral reserve by proper feeding and the addition of a mineral mixture to her ration should the foods fed be likely to be deficient in minerals. The mere fact of a cow having a good reserve will not, in itself, prevent parturient collapse, because, although the store is there, the system is unable to draw upon it.

Treatment—The modern line of treatment is to give a massive injection of a calcium solution at the very first onset of symptoms. It is doubtful if this treatment gives better results than the old-fashioned practice of inflating the udder either with air, or oxygen. When this method of treatment is adopted care must be taken to use only sterilised teat syphons and not to introduce infection into the udder. In addition, to prevent excessive bloating up, the subject must be propped up on her breastbone (sternum) and maintained there either with bales of straw or sandbags. On no account must a drench be given until the cow has become fully sensible otherwise she may either choke or develop an attack of broncho-pneumonia. If bloating does become excessive the gas must be drawn with a trocar and canula.

Grass Tetany or Lactation Tetany, etc.—This is a condition following the drop in the level of the blood magnesium, and occurs mainly in stall-fed cattle when first turned out to grass but the exciting cause of it is still largely a matter of doubt. As in milk fever it is a temporary breakdown in the endocrine nervous mechanism which normally keeps the constituents of the blood at the proper level.

Symptoms—Usually ushered in by very great excitemen amounting even to violence. Fits and convulsions followed sooner or later by insensibility and death in a comparatively short time. As in milk fever it is sometimes, but not always associated with a drop in the level of the blood calcium as well To guard against this possibility many veterinary surgeons now treat this condition by the injection of both magnesium and calcium solutions. There is little that the owner can do except to send for the veterinary surgeon immediately and try and restrain the subject from doing violence to herself o others.

Hoose or Husk, or Verminous Bronchitis—This is caused by the presence of fine threadlike worms in the bronchial tube and windpipe and is most frequently seen during the lat summer and autumn, but may occur at any time of the year. Although young cattle suffer most severely from the infestation, older cattle are by no means exempt and although they may not suffer any very obvious ill-effects act as reservoirs for the spread of the trouble over the pastures.

Symptoms—A characteristic husky cough easily excited upon movement and in severe cases loss of condition is rapid. When the bronchitis is severe there is a discharge from the nostrils. In older cattle a cough may be the sole symptom.

Treatment—Affected animals must be taken off, and kept off, the infested pastures as otherwise re-infestation is bound to occur continually, and many deaths from pneumonia may be expected. There is no medicine which, when given by the mouth, can reach the lungs in sufficient concentration to do any harm at all to the worms, and, therefore, the medicine must be injected directly into the windpipe which is a job for the veterinary surgeon. If professional assistance is not available, half an ounce of chloroform may be poured on to a sponge and placed in a nose bag and the latter put on and kept on the animal to be treated until it staggers or falls down when it must be removed at once. An alternative is to place a heated brick in a nosebag and sprinkle on it a few crystals of iodine and then allow the animal to inhale the fumes until it is nearly suffocated. In any case, if the calf shows signs of pneumonia by heavy and distressed breathing and rise of temperature no time should be lost in sending for the veterinary surgeon as the calf will need a course of M. & B. or possibly even a dose of anti-serum and vaccine. On badly infested land the worms persist for at least a year and cattle of all ages should be kept off such land for at least 12 months.

Red Water or Bovine Piroplasmosis—Red water or bovine piroplasmosis, is caused by minute parasites entering the blood and destroying the red cells. It is the colouring matter from these broken down cells which give the colour to the urine and this may vary from red to coffee-coloured. It should be noted that in red water there is no free blood in the urine, only the colouring matter of it. The infection is carried by ticks which have fed on an infected animal, inoculating the organisms into a healthy one when they feed on it and this is the only way in which the disease can be contracted, so, therefore, no ticks, no red water.

Treatment—Treatment should invariably be left to the veterinary surgeon as the disease may be cured quickly and safely by the intravenous injection of one of the newer remedies. The stock owner's part is to keep the patient comfortable and remove any ticks which may be upon it, tempt the appetite, regulate the bowels by the addition of black treacle to the food— 1 lb. to 2 lb. a day—and encourage it to drink large amounts of cold water, linseed tea, hay tea, or barley water. Thirst may be induced by the addition of salt to each one of its feeds, or, if the animal is off its feed, by mixing salt with some black treacle and putting it into the mouth with a spoon.

Prevention—As ticks favour for their hiding and breeding places rough grass, scrub, bracken, etc., these should be eradicated by burning and grubbing, and sheep, which do not suffer from bovine piroplasmosis, may be used as tick collectors and purifiers, the sheep being dipped at regular intervals to rid them of the parasites. It is claimed that spraying cattle with one or other of the approved dips containing D.D.T. and gammexane not only kills any ticks which may be upon them but gives them protection against ticks for some little time.

Black Quarter—Black quarter is a contagious disease caused by spore-forming bacillus—the bacillus of black quarter or the B. chauveii. It is also called B. sarcophysematos bovis, and lives in the soil until such time as it gains entrance to the animal body through some small wound. The disease is not directly contagious, in fact, in fields separated by only a wire fence the disease may occur in one year after year and never in the other. Animals from six months of age up to 2½ years are chiefly affected.

Symptoms—Sudden deaths are common in young stock without any previous symptoms having been shown, but usually affected animals separate themselves from the herd and are seen to be lame in one or more limbs which, upon examination are found to be swollen, hot and painful. At first the swelling are doughy to the feel and pit on pressure, but rapidly becom puffed up with gas which forms in the tissues and emit crackling sound when pressed. Later still, the swellings becom cold and insensible and may even burst open. When cu a dark frothy evil-smelling fluid and gas, smelling like ranci butter, escapes.

At first there may be a rise of temperature, but later it become subnormal. Eventually the animal falls down, refuses or unable to get up, becomes insensible and dies in a coma. Th usual course of the disease is 24 hours or less. It should b noted that sheep also suffer from this disease which may attac them at any age.

Prevention—The disease may be prevented by inoculatio but this must be done for at least 15 days before they are turne on to an infected pasture and exposed to infection, and as th immunity produced diminishes as time goes on cattle shoul be re-vaccinated every six months until 2½ years of age.

The carcases of animals which have died from the diseas should be burned and *not* buried. In the event of an ou break all animals in an infected field may be given a dose of the anti-serum which gives protection for a limited period of time.

Treatment—In the case of very valuable animals the effect of massive doses of the anti-serum may be tried and also injections of Penicillin. On the whole, there is no treatment.

Actinobacillosis and Actinomycosis or Wooden Tongue—This is a disease due to the presence in the tissues of small bacilli usually arranged in a radiating manner, and infection occurs through small wounds or abrasions made by foreign bodies, barley haulms, bits of straw, etc., or while cattle are changing their teeth. The most usual sites for the disease are the tongue, skin of the throat, and gums. It may also be found in the salivary glands, udder, lungs or in skin lesions.

A closely allied disease and often mistaken for actinobacillosis is actinomycosis which is due to a fungus which more often attacks bony structures, the jaws and face, more rarely the glands or tongue, etc.

Symptoms—The tongue becomes enlarged, stiff and hardened, and ulcers frequently appear upon its surface. There is much dribbling of saliva from the mouth and the prehension and mastication of the food is rendered difficult. When the glands become affected they become enlarged. In some cases although they gradually become larger the disease remains stationary, but sometimes the glands burst and a large tumour mass breaks through the skin, sometimes as large as a man's fist and the thick, creamy pus is discharged. In actinomycosis the affected bones become enlarged, suppuration occurs with a protrusion of large tumour-like masses. The popular name for actinomycosis is "Lumpy Jaw."

Treatment—Actinobacillosis is the more amenable and a cure may be effected either by the internal administration of potassium iodide or the injection of a specially prepared iodine solution into the veins. Penicillin is said to give good results. The same treatment may be applied to actinomycosis, the penicillin in this case being injected into the tumours. Surgical methods are sometimes employed for the drainage of the abscesses, the removal of dead bone or the removal of enlarged lymphatic glands, this being a much better way of dealing with these enlargements than the old method of blistering.

SOME COMMON DISEASES OF SHEEP

Sheep Scab—See under Scheduled Diseases.

Sheep Lice and Keds—These insects cause much irritation of the skin and may give rise to loss of condition. The wool may be damaged or rubbed off in parts, the animals rubbing and scratching to relieve the irritation. Both lice and keds may be eradicated by dipping in the dips used for scab. Dipping for scab proves to be of double benefit.

Ticks—Sheep may become infested by the common sheep ticks which, in some districts, are the carriers of the virus which causes louping-ill, tick-borne fever and pyæmia in lambs and hence of considerable importance to the shepherd. They may be destroyed by dipping in one of the improved dips put on the market for this purpose or by dusting with derris root powder in the case of newly born lambs.

Louping-Ill—Louping-ill, sometimes called the trembles, or the jumps, is an infectious parasitic disease caused by a virus which is carried by ticks from one sheep to another. It occurs chiefly in parts of Scotland, England and the north-west of Ireland and with the greatest severity between March and June and September and October, although cases may be met with in other parts of the country and at other times of the year.

The disease occurs in two forms—acute and sub-acute. In the former symptoms may appear from 4–6 days after the sheep have become infested with the "carrier" ticks. The sheep becomes uneasy, gets up and down frequently during the day ; if the temperature is taken it is found to vary between 104° and 107° F. During the next week or ten days nervous symptoms develop as shown firstly by timidity and later the muscles of the jaw and neck begin to twitch and quiver ; there is frothing at the mouth ; if made to move rapidly or turn suddenly the animal staggers and may fall down and, as time goes on, the subject makes jerky jumps from all four feet at the same time, landing on all four feet again. Such symptoms are easily noticed especially when they are being driven by a dog. Later, the animal becomes paralysed, quite unable to stand, quickly becomes unconscious and dies in a coma.

In the sub-acute form the symptoms are not so urgent, but the subject is noticed to take very high steps with its forelegs, holds its head very high, sometimes carrying it to one side ; the pupils of the eyes are dilated, and the sheep shows great fear when caught ; the trembling of the muscles, staggering and falling, and, maybe, paralysis—partial or complete ; at first condition is lost slowly but later very rapidly and unles fed by hand may die from starvation. By hand feeding i may be kept alive for as long as two months. A certain number of sheep recover and become more or less immune to further attacks, but the disease usually leaves traces behind in the way of altered gait and head carriage.

There is no treatment, but sheep may be protected agains the infection by inoculation with a vaccine prepared for th purpose. Attempts should be made to keep down the tick population as far as possible by regular dippings.

Tick-Borne Fever—Tick-borne fever is yet another virus disease carried by ticks also in louping-ill districts, and has, in the past, been confused with that disease. Apart from the loss of condition of infected subjects it may give rise to abortion and infertility. There is no treatment.

Pyemia of Lambs—Newly born lambs frequently die from a bacterial infection and blood poisoning should they become heavily infested with ticks. The losses arising from this condition may be high. Therefore lambs born on badly tick-infested land should be turned up and have their bellies well dusted with derris root powder which not only destroys the ticks but keeps them off for some considerable time.

Scrapie—Scrapie is a disease of sheep localised to the English and Scottish borders and has been known by border farmers for generations. All breeds of sheep are susceptible. The majority of cases occur in sheep between 18 months and two years, but rams, ewes, wethers and sometimes even lambs may fall victims. Caused by a virus, the manner in which infection is transmitted is still a matter of debate.

Symptoms—Skin symptoms develop first and consist of a marked irritation—the sheep rubbing itself against any suitable object and showing pleasure when rubbed with the fingers. In consequence of this the fleece becomes damaged and as the irritation increases much of the fleece may be rubbed off, becomes very ragged and large patches of bare skin are left. Nervous symptoms follow those of the skin, infected sheep raising their heads with ears inclined backwards as though listening to something ; the head is carried high, and there is a peculiar high action of the front legs when running and when at rest the body is often seen to be in a state of trembling or shivering. At this stage if the sheep is startled, fits and convulsions may be excited followed in many cases by paralysis. Death occurs from general exhaustion.

Treatment—None.

Fluke Disease, also known as Rot, Coathe and Bane—This is caused by a trematode parasite, the fasciola hepatica, which invades the liver in the bile ducts of which the female produces thousands of eggs which in due course pass out with the excreta. From the egg hatches a small ciliated larva called a " miricidium." The egg hatches out in water and the larva, which is free-swimming, finds its way to the body of a water snail—" limnea truncatula." Further stages of development take place in the body of the snail, the last stage being a tadpole-like creature, or creatures—" cercaria." These leave the body of the snail, climb up blades of grass, herbage, etc., lose their tails and encyst themselves, and may be seen as white specks on the grass, etc. After these cysts are taken in with the food the young flukes hatch from them in the intestines. From here they migrate to the surface of the liver into which they bore and penetrate, finally gaining the bile ducts where they become mature and complete their life cycle by producing eggs. The water snail plays an essential part in the life cycle ; if there were no snails there would be no fluke disease.

In very heavy infestations the damage done to the liver may be so extensive, the lamb or sheep dies from internal hæmorrhage, and the liver is found to be just a pulpy mass on post mortem examination. In some parts of the country fluke disease is associated with what is called " black disease " which is a fatal toxæmia with a very high mortality rate caused either by the young flukes carrying bacteria (clostridium eodematians) into the liver or activating the spores of those germs which may be already present in that organ, the result being that areas of the liver become necrotic, pulpy and disorganised. It has been found that sheep may be given a high degree of protection against this complication of fluke disease by inoculation by a special vaccine and, in the event of an outbreak, further deaths *may* be prevented by the injection of a black disease anti-serum. There is no other treatment.

Treatment—The treatment consists of the administration of a 1 cc. capsule of carbon tetrachloride at the beginning of the Fluke season, September to October, and in badly affected districts this may be repeated at monthly intervals, but usually two treatments during the winter are sufficient. Other drugs used in the treatment of fluke are : Danistol, which is a purified extract of mal fern and is put on the market in capsules of dosage suitable to th age of the animal to be treated. This drug may also be use for cattle which are not tolerant to the first-named drug. A still more recent remedy is hexachlorethane, which may b used for both sheep and cattle, given as a drench two or thre times during the fluke season.

For cake-fed sheep carbon tetrachloride may prove poisonous and when numbers of sheep are to be treated it is advisabl to try the effect on two or three sheep before dosing the whol flock. It has been reported that sheep poisoned by carbo tetrachloride may be saved by the intravenous injection of calcium solution, or, later still, by dosing with sulphanilamid which has been found to protect the liver against the tox action of carbon tetrachloride.

Foot-Rot in Sheep—Foot-rot proper is a contagious diseas primarily affecting the soft tissues of the foot so that it necessary to distinguish between this and what is commonl known as foot-sore which is due to infection entering t foot through injuries to the horn, splits, bruises, etc., and which affects the individual rather than the majority of the flock as in the case of foot-rot. The germs responsible for foot-rot are present in the soil and may be carried by sheep from pasture to pasture. Diseased sheep are a constant source of infection to healthy ones.

Symptoms—The first noticeable symptom is usually lameness and if an affected foot or feet is examined a wet sore may be found between the claws which exudes a foul-smelling discharge. In most cases it is possible to diagnose foot-rot in a flock by the nose as well as by the sight. If not dealt with this sore becomes enlarged, extends up into the coronet and the infection may penetrate deeply into the foot and involve the bones, tendon sheaths and tendons. The horn of the hoof may become separated from the sore tissues, be underrun by pus and discharges and abscesses may form around the coronet and in the hollow of the heels in bad cases. Lameness is excessive, affected subjects lose condition rapidly, and the worst cases may die from septic infection.

Treatment—Before applying any dressings it is necessary to carefully pare away detached and decayed horn to give free exit to discharges and allow the dressings to penetrate the site of the infection. Abscesses must be lanced freely. The most modern line of treatment is by intravenous injection of one of the soluble sulphonamides such as sulphathiazine sodium or sulphathiazole soluble, and the application of a sulphonamide powder mixed with an antiseptic powder. Penicillin has given good results in some cases. The ordinary line of treatment is to walk the subjects through a shallow footbath containing a ten per cent. solution of sulphate of copper in water, and, in the event of an outbreak the whole flock, both infected and healthy, should be walked through such a bath every day for a week until the last case has cleared up. Exceptionally bad cases in which much paring and cutting has had to be done may require individual treatment and the affected foot enclosed in a boot.

Entero-Toxaemia—This is also called " strike " or " struck " and most usually affects sheep in good condition, fat lambs, etc., the subjects usually being found dead without exhibiting any symptoms. It is caused by soil organisms of the clostridium welshii group which multiply very rapidly in the intestines and produce toxins which quickly invade the blood stream. In subjects dead from this disease decomposition sets in early and, depending on the strain of the organisms, which may be mixed, the kidneys are frequently found in a putrid and pulpy condition. Although pulpy kidney disease may occur separately from entero-toxæmia there is no cure for either condition, but on farms where these diseases occur protection may be given by vaccination or inoculation. In the event of an outbreak lives may be saved by the injection of the whole flock with anti-serum. On farms in which both diseases have occurred a vaccine anti-serum containing both strains of organisms may be used and is now available.

Lambing Sickness—Lambing sickness is a hypo-calcæmia comparable with parturient collapse (milk fever) in cattle, and may affect ewes before or after lambing. As in the case of milk fever in cattle, lambing sickness is not a true deficiency disease for there may be an adequate supply of calcium salts stored up in the skeleton but unavailable to the subject which is unable to keep up the level of the blood calcium.

Symptoms—Dazed condition with uncertain gait, refuses food and moves uncertainly. As the trouble progresses the ewe goes down, becomes insensible and dies in coma.

Treatment—The treatment, as in milk fever, consists of injections of a calcium solution frequently combined with glucose when the subject is carrying twins in case she may be suffering from "twin lamb disease" or "pregnancy toxæmia." The initial symptoms are similar to those of lambing sickness and the diagnosis in the field is by no means so easy as would appear on paper. As in the case of milk fever no medicine should be given by the mouth while the animal is insensible.

Pining, also known as Moor Sickness, Border Pine, etc.—This occurs in districts where the soil is deficient in cobalt as in parts of northern England, Scotland, Cornwall and elsewhere. On "pining" farms all ages of sheep are affected but young growing lambs suffer most and their condition is often aggravated by heavy worm infestations, which, at one time, were thought to be the cause of the trouble by producing an anæmic condition and scouring. Deficiency of iron was also thought to cause the anæmic condition which to some extent and in some districts, may be more or less true since traces of cobalt and copper are necessary for the full utilisation by the body of what iron there may be contained in the foods. In other words, pining is not always a single condition but a combination of causes.

Symptoms—Lack of thriving, dullness and lack of vitality of the fleece. Growth is stopped, weight is lost, and anæmi shows itself by the paleness of the mucous membranes. Affected animals are easily fatigued. An affected animal has a dejected appearance, there is discharge from the eyes and the head is carried low. Scouring is seldom seen in a pure case o "pining" and is an indication that the trouble may be compl cated by parasitic infestation.

Treatment—Make good the deficiency of cobalt which i some parts of the country may be done by removing the sheep to pastures known to contain a sufficiency of this trace element. Here the soil chemist may prove useful to sheep breeders. It has also been found possible to raise the cobalt content of the soil by dressing with 2 lb. to 4 lb. cobalt chloride or sulphate to the acre, but this is more easily said than done unless the cobalt is mixed with some fertiliser or inert substance to allow even distribution. In some cases the deficiency may be rectified by the use of mineral licks containing cobalt although there is frequently some difficulty in persuading the sheep to use the licks. Sheep and lambs may be individually dosed by tablets containing the necessary amount of cobalt and which are sold under the name of "Trace Element Tablets."

In order to avoid pining it is essential to ensure an intake of a few milligrammes of cobalt every day, but how this is to be provided depends on the situation of the farm and the management of the flock.

COMMON DISEASES OF PIGS

Probably the most important disease of pigs is swine fever which has already been dealt with in the section on Scheduled Diseases (page 393).

Swine Erysipelas—Also known as diamond disease, red soldier and pig measles. The latter is perhaps unfortunate as "measley" pork has nothing to do with swine erysipelas but is descriptive of the presence of tapeworm cysts in the muscles. Swine erysipelas is an infectious disease caused by the bacillus rhusiopathiæ suis. It is characterised by a high fever, lack of appetite, reddish or purplish spots on the skin very often in the form of diamonds, by general debility, lameness, and in chronic cases which have survived an acute attack, there may be difficulty in breathing due to heart disease. It occurs in acute and chronic forms, the subjects of the chronic form usually being animals which have survived an acute attack but have not fully recovered. Such animals are usually in a poor and unthrifty condition or otherwise "wasters." Although little pigs may sometimes become affected it more usually attacks fat pigs which are about ready for market, thus differing from swine fever in which all ages of pigs are susceptible. The incubation period may be as short as 24 hours or as long as five days, three days being the average.

Symptoms—In mild cases the pigs appear miserable and dull, lack appetite, have increased thirst and may be constipated. A skin eruption develops on various parts of the body, especially on the chest, back, neck, and outside the thighs. The skin may be uniformly discoloured dark red to purple, or in patches, or in spots which are sometimes circular, sometimes quadrangular, sometimes diamond-shaped. Usually improvement occurs after the development of this rash or eruption and the pigs make good recovery in a week to ten days, but in other cases the skin eruption may take a serious turn and portions of the skin may slough away and sometimes the tips of the ears and tail drop off. In acute and severe cases the usual signs of severe illness in a pig are present, namely, shivering, high fever, loss of appetite, vomiting and at first constipation followed by diarrhœa or scouring. The pigs try to hide themselves by burrowing into the litter and lie in a state of collapse and exhaustion. In the worst cases death may occur quite suddenly, but usually the course of the disease is slower and the red patchy, diffused discoloration of the skin of the buttocks, thighs, body and ears occurs, the rate of respiration is greatly increased and pigs when made to walk stagger about as if intoxicated. In cases about to terminate fatally the temperature drops suddenly to sub-normal and the pigs die in coma in three to four days. Animals which survive but do not fully recover remain unthrifty and may eventually die from heart disease or be lame from enlarged and swollen joints, but those that do fully recover become immune for life.

Treatment—There is no drug or combination of drugs which has any effect upon the disease, but where the value of the pigs warrants the expense they may be successfully treated by injections of the anti-serum and penicillin. Penicillin alone frequently brings about a cure, or, at least, the survival although inflamed and swollen joints are likely to occur unless the serum is given in addition.

Prevention—In the event of an outbreak the in-contacts o affected animals should be given an injection of the anti-serum and this repeated later on with or without an injection of the vaccine depending upon whether the temperature remain normal. If still running a temperature the vaccine is omitted until later on. It should be noted that both the dung and th urine of infected pigs contain the bacilli in great numbers and therefore, in order to make infected styes safe for futur use, they must be *very* thoroughly cleaned out and disinfected and all litter, etc., removed and burnt and on no account sprea on the land since these germs may remain virulent from yea to year. Pigs likely to become exposed to infection may b inoculated by vaccination well ahead of the time that the diseas usually makes its appearance, and all newly brought-in pig or those returning from market should be kept isolated fro all other pigs on the place for twice as long at least as th incubation period. All swill, offals, etc., fed to pigs shoul be well boiled before use.

Deficiency Diseases of the Pig—These are brought about b a deficiency of vitamins and minerals in the diet of the pi or the inability of the pig to make use of what the foods do contain. This applies more expecially to the mineral content.

Rickets—In this disease the bones remain soft and pliable and liable to deformities from imperfect ossification. This is due to a lack of vitamin "D" and calcium salts in the diet. Lack of vitamin "D" may be aggravated by a deficiency of both vitamin "A" and vitamin "B" complex, and a still further aggravating cause is the improper calcium-phosphorus ratio in the ration. In addition to the bone deformities, namely, bowed legs, enlarged joints, etc., there is a condition of general debility, lack of bloom on the skin, although in some cases over-fat youngsters may be subject to rickets when fed on a fattening diet. Lameness is often a frequent symptom in addition.

Contributory causes are damp, cold and dark styes or habitations. The trouble is seldom encountered in pigs raised on the extensive system which obtain the benefit of the ultra-violet rays of the sun.

Treatment—Once the bones have become ossified and solid there is no treatment for the deformities which occurred whilst they were soft and pliable. Every care should be taken therefore to prevent the incidence of rickets by proper housing and management, and the addition of cod liver oil and a mineral mixture to the sow while she is carrying and suckling her young. Litters of pigs born during the dark days of winter should have cod liver oil and a mineral mixture added to their ration when they commence to feed for themselves. The mineral mixture may be omitted if white fish meal forms about 10 per cent. of the ration ; in addition the piglets should run in the open and get unfiltered light for as long as possible every day. If, however, the disease does appear in spite of these precautions additional minerals and 5 per cent. dried brewers' yeast should be added to the ration in addition to the cod liver oil, etc. Exposure to the rays of the sun is even more important.

A serious deficiency of vitamin "A" may result in non-thriving, scouring, leg weakness and sometimes convulsions and sometimes even complete paralysis, but this is not at all likely to occur when pigs are fed on plenty of green food or cod liver oil is included in their food. A deficiency of vitamin "B" complex may result in poor condition and skin irritations whilst with serious deficiency or total lack of this essential vitamin fits, convulsions or paralysis may result. This, however, is not likely to occur in freshly prepared feeding meals, or when crushed or whole grains are fed. It may be prevented entirely by the addition of dried brewers' yeast to the ration which is also a valuable source of protein.

Piglet Anæmia—This is due to the inability of the sow to provide her piglets before their birth with a sufficient reserve of iron to carry them over until they commence to feed for themselves, and can obtain their own supplies. This failure may be due to an actual lack of iron in the diet of the pregnant sow or to some inherent characteristic of the sow herself The trouble usually makes its appearance during the first week of life, but may occur at any time up to weaning. The symptoms are scouring and anæmia as shown by pallor of the visible mucous membranes. Affected pigs do badly, the death rate may be high, and the survivors seldom do well in after life as any setback occurring during the suckling and growing perio is seldom, or never, made good.

Treatment—It is useless adding an iron-containing minera mixture or dosing the sow with preparations of iron as thi mineral does not reach the piglets in sufficient amount throug her milk, and consequently they must be provided with iro direct. Treatment should commence during the first wee after birth and continue until weaning time, possibly longe if pigs are kept "styed up." Modern treatment is to give on massive dose of reduced iron in tablet form since it has bee found that iron is stored up in the body, or small doses of iro may be given every day or two either in tablet form or a Parrish's Syrup, etc. Another treatment which is quite effectiv consists of smearing the teats and udder of the sow twice dail with :—

Sulphate of iron	3¼ oz.
Sulphate of copper ...	¾-oz.
Water	1 pint
Black treacle	1 pint

The salts are first dissolved in hot water and then added the treacle.

In addition it is an advantage to get these pigs out into th open as soon as possible where they can obtain grass and eart and where this is not possible a turf may be cut every day ar thrown in to the pigs.

Pneumonia—Pneumonia or inflammation of the lungs is frequent cause of fatalities amongst young pigs which a extremely susceptible to extremes of temperature, cold ar damp, especially when newly born. It is difficult to mainta the optimum amount of ventilation and warmth in a sty b experience shows warmth to be of greatest importance. Pi reared in the open in weather-tight huts with earthen flo and provided with plenty of dry clean litter seldom, if ev suffer from pneumonia pure and simple, although, of cour they may do so during the course of some other disease such piglet influenza, etc.

Symptoms—Affected pigs go off their feed, breathe heavily and cough. If the visible mucous membranes are examined they are at first found to be reddened and congested, and later on as the aeration of the blood becomes more imperfect they take on a purplish tinge. In young pigs the course of the disease may be very rapid, may be a matter of a few hours only or two or three days at the most, and subjects which survive are left unthrifty and with a chronic cough.

Treatment—The first essential is a warm, dry place for the affected pigs to sleep in. They do better in a hut in the open than in the ordinary farm pigsty or in the Danish type of pighouse. Most cases respond to a few days course of M. & B. 693, and in some cases penicillin may be indicated, but both of these remedies must, of course, be obtained from a veterinary surgeon and should only be used under his supervision. Later the general condition of the survivors may be improved by a daily course of cod liver oil and a mild tonic such as Parrish's Food.

Piglet Influenza—An infectious disease caused by the virus "haemophilis influenzae suis," usually complicated and aggravated by secondary bacterial infections. It is contracted only by droplet infection, and the sow which has recovered from the disease may, or may not, be a "carrier." It affects pigs up to the age of four weeks, and leads, if not fatal, to chronic sickness, a chronic cough, and unthriftiness. Pigs kept in cold, damp houses suffer most, and it is most prevalent on farms in which sows are farrowed down in community or Danish type pig houses and where young pigs are allowed to feed together from a common trough. Losses may vary from 20 to 40 per cent.

Symptoms—Coughing and sneezing. The pigs are disturbed and in some cases scouring and these are followed by symptoms of pneumonia. Survivors are troubled with attacks of coughing for months after weaning, and if exposed to adverse climatic conditions or unsuitably housed, are liable to contract pneumonia and die.

Treatment—There is no specific treatment but M. & B. is frequently given to control secondary infections.

Prevention—The disease can only be prevented from spreading throughout the herd by farrowing down sows in separate huts and runs, separated from one another by a "no-man's land" of at least 6 feet. The affected pigs should remain in these runs until they are removed to the fattening styes.

Bowel Oedema—Although this disease has been recognised in Northern Ireland for many years it is only comparatively recently that it has become more prevalent in this country. The cause has not yet been discovered although it appears to be closely associated with a change of food and environment. The most susceptible age is from 10–16 weeks, but no evidence has been produced that the disease is either infectious or contagious.

Symptoms—In most cases the first thing noted is the pig refuses food and the upper eyelids are seen to be swollen (œdema). This is followed sooner or later by a staggering and uncertain gait, or inco-ordination of movement. At first either the front or hind limbs may be affected, and sooner or later they become paralysed. In some cases this inco-ordination of movement is the first sign of the trouble. Sudden death may occur, but the usual course of the disease before death supervenes is from 12 to 18 hours, or, in any case, within 36 hours.

When œdema of the larynx occurs the grunt and voice of the pig becomes altered and hoarse. In some outbreaks only one pig or litter may be affected, but sometimes the whole of the piglets become affected and die. A puzzling feature of the disease is it may break out amongst pigs for no apparent reason, there having been no change of food or housing. It may occur in any month of the year in spite of varying climatic conditions.

Treatment—So far the disease has not responded to penicillin or the sulphonamides, and though recoveries have occurred when the diet has been changed to sloppy bran mash only, recoveries have also occurred spontaneously with no treatment at all. No doubt it is only a question of time before satisfactory treatment will be discovered.

PARASITIC INFESTATIONS OF THE PIG

External Parasites—The skin of the pig may be infested by lice (hæmatopinus suis) which are blood suckers and the largest known amongst the pediculinæ. The presence of this louse on the skin gives rise to great discomfort causing an irritation proportionate to its size and giving rise to the formation of red papules which by the efforts of the animal to relieve the irritation frequently become raw. As in other parasitic infestations of the skin the itching becomes severe at night thus depriving the subject of rest and sleep to such an extent that a severely infested animal, if not relieved, may die from exhaustion and anæmia. This applies more particularly to young pigs.

The parasites are to be found on practically any part of the body and frequently formed in clusters around the base of the ears.

Other skin parasites visible to the naked eye are fleas, harves bugs and poultry red mite which, however, are usually onl transient visitors.

Treatment—Lice and nits are easily eradicated by Derris washes or by a watery suspension of benzene hexachloride or even by dressing the pigs all over with "pig oil." If the appearance of the pig is not important waste oil from the motor car sump may be used.

Mange—The pig normally only suffers from one variety of mange caused by the "Sarcoptes scabiei var. suis" which is one of the burrowing mites, the female burrowing tunnels into the skin to deposit her eggs. It is spread by direct or indirect contact.

Symptoms—From the first intense pruritis (itching) is a prominent symptom. The skin becomes red and covered with small red papules: there is loss of hair; formation of scabs and crusts, and, as the disease progresses the skin becomes thickened, corrugated and fissured. As a rule the trouble commences on the head, the base of the ears, the face, and then spreads backwards to the croup and the inside of the thighs, and if unchecked it may spread all over the body. Death from exhaustion and wasting may occur in neglected cases or when little pigs are attacked.

Treatment—Although sulphur ointment or a wash made by dissolving 1 oz. of potassium sulphurate in a gallon of warm water, applied to or three times weekly, effects a cure, it is claimed that spraying with a 0·5 per cent. watery suspension of benzene hexachloride effects a cure in two or three sprayings at seven to ten days intervals. In advanced cases whatever application is selected the skin must be most thoroughly cleansed with hot water and soft soap before the remedy is applied. In addition, the sty, rubbing places, etc., must be scraped and scrubbed clean with hot water and soda and then thoroughly disinfected.

Internal Parasites—The pig may harbour quite a number of intestinal parasites but can claim no tapeworms as its own.

Coccidiosis—This is an inflammation of the bowels caused by protozoan parasites known as coccidia with the usual symptoms of scouring and wasting and sometimes dysentery. It is not very common in this country, but when it does occur it may give rise to great mortality in young pigs. The treatment is by a three or four day course of sulphamethazine or sulphathiazole.

Worms—Signs of a worm infestation may be either loss of appetite or a voracious one, constipation or scouring, wasting, fits or convulsions, and in nearly all cases a pallor of the visible mucuous membranes. The most common worm affecting pigs is the "ascaris suis" or "ascaris lumbricoides" which attains a length of about 8 to 10 in. (the male being only about 6 in.) and is dirty white or reddish in colour. The other round worms of the pig with the exception of "trichina spiralis" are of little or no importance in this country. Trichina spiralis does little harm to pigs whilst in the intestines. From thence the larvæ migrate to the muscles where they encyst and give rise to symptoms of rheumatism or even to paralysis if in sufficient numbers. When humans eat such infested pork they may become affected with the disease "trichinosis" which is very painful and frequently fatal.

Treatment—The treatment for round worms is the administration of a mixture of oil of chenopodium 5 parts, castor oil 95 parts, given to the fasting animal individually in doses from half a tablespoonful to three tablespoonfuls proportionate to age and weight. Commercial sodium fluoride mixed with the food at the rate of 1 per cent. of the dry meal is claimed to be a very effective remedy, but on the whole the administration of worm medicines with the food proves neither safe nor satisfactory.

Lung Worms—Verminous Bronchitis—One of the complications associated with ascarid worm infestations is a bronchial pneumonia—more or less severe—according to the number o parasites which find their way into the lungs. This is cause by the larvæ of the worms which, after hatching out from th egg in the intestines, find their way into the general circulatio and finally into the liver, heart and lungs where they remai for a certain length of time before completing their migratio back to the intestines.

Symptoms—A husky cough, and those of pneumonia, heav breathing, etc., and what is commonly called "the thumps." Again, depending on the massiveness of the invasion, infecte subjects become unthrifty, waste and may eventually die Young pigs suffer most severely and may receive a setbac from which they never fully recover.

Treatment—There is no treatment for the removal of th larvæ from the lungs. The pneumonia, which is a secondar condition, may be treated with penicillin, or the sulphonamide followed by a course of cod liver oil and tonics to improve th general condition.

Parasitic Bronchitis—Parasitic bronchial pneumonia prop is caused by the presence in the bronchial tubes and windpip of two "lung worms"—the "metastrongylus apri" and th "m. brevi vaginatis"—the eggs of which may be either coughe up and out or swallowed and passed out with the dropping

Symptoms—These vary with the number of worms prese but they are a troublesome moist cough, easily excited c movement, and unthriftiness.

Treatment—The removal of the worms from the bronchi tubes, etc., may be effected by chloroforming the pigs insensibility as medicines given by the mouth do not arrive in the lungs in sufficient concentration to have any affect on the worms. At the same time worm treatment for the removal of intestinal worms is called for and the bronchial pneumonia may be treated as already recommended.

Prevention—The prevention of worm infestations in a pig calls for an intensive cleaning up of the floors of the styes and those parts soiled by the droppings, followed by spraying or wasting with a very strong solution of washing soda and boiling water to destroy the worm eggs upon which the ordinary disinfectants have no appreciable effect. It is advisable also to worm "in-pig" sows about 15–10 days before they are placed in the farrowing styes, and to cleanse their hindquarters, bellies and udders with warm soap and water to remove any worm eggs which may be adhering to the skin. The sows may be wormed by a 10-grain dose of santonin shaken up with a little milk or thrown on the back of the tongue.

COMMON DISEASES OF THE HORSE

A thorough knowledge of the conditions of health is of the utmost importance because only by a knowledge of what is right can one detect a condition which is wrong. A person who has made a study of the normal habits and behaviour of a horse is in a better position to know when something goes wrong than one who takes but little interest in his animals except for the work they do.

Lameness—"Lameness" signifies any deviation from the normal mode of progression, however slight, and from whatever cause.

Although the discovery that an animal is lame, or is going lame, is an easy matter to discover, it is by no means so easy to locate the seat of the trouble by the eye alone and until the exact site of the trouble can be located effective treatment is impossible. The foot is perhaps the most common site of lameness. It may be due to so-called "corns," which are in reality only bruises of the sole in the angle formed by the wall of the hoof and the bar and due to pressure by the heel of the shoe, to bruises of the sole from rolling or picked up stones or to picked up nails. Other causes are, laminitis, or fever of the feet; navicular disease; sidebones, and low ringbones. Foot lameness is usually indicated by the horse while standing in the stable resting or pointing the affected foot and in extreme cases being unable to place any weight on it thus lifting it up and down more or less continuously. Foot lameness may be accompanied by a rise of temperature as in the case of laminitis or of a punctured wound penetrating the pedal joint, or when suppuration is going on within the horny box of the foot.

A horse lame in front, when led towards the observer standing in front of it, nods his head when the unsound leg comes to the ground, this being due to the horse's efforts to put as little weight as possible on the affected limb. This nodding can be seen also when the horse is led away from the observer in a straight line. When a horse is lame behind he is seen to carry the affected limb higher than the other. While making these observations it should be noticed whether all the joints of both fore and hind legs are working normally or if there is any reluctance on the part of the animal to flex or bend any of the joints. It is not possible in these short notes to go into all the details of the various possibilities and their causes, the main point being to recognise that the horse is lame and the approximate location of the trouble. Except in experienced hands home treatment of lameness is usually a waste of valuable time and a lame horse should be treated by a veterinary surgeon.

Colic—Colic, or " pain in the colon," is a term used indiscrimately to describe any pain in the abdominal organs. Although there are several different kinds of colic it is sufficient to mention the two most common forms, spasmodic and flatulent or " windy colic."

Spasmodic colic, which is also called " the gripes," comes on suddenly with violent attacks of pain during which a horse may throw itself about violently and get up and down continually. During the intermissions of these spasmodic attacks the animal may appear to be almost normal or remain a little uneasy. Then the previous performance is repeated. Many horses seek relief by rolling over, or attempting to do so. The cause of this form of colic may be hunger, over-fatigue, being exposed to wet and cold while sweating, or even by giving a tired and sweating horse a large drink of cold water while in the stable. A horse on the road, or while working, however hot and tired may be safely given all the cold water it likes to drink. In fact a horse under such conditions should be offered water at every possible opportunity.

Flatulent Colic—In flatulent colic gas forms in the intestines, sometimes the stomach, from the fermentation of the food and much distress is occasioned by the great distention of the bowels by what is commonly called " wind." The pain is not so violent but more continuous than in the case of spasmodic colic, and although the horse may get up and down and attempt to roll it does so much more carefully and with less violence The pressure of the distended intestines on the diaphragm may give rise to distress in breathing and if unrelieved may cause suffocation.

A significant symptom of both varieties of colic is the refusa of the subject to drink, although in between the attacks of pain it may nibble a little hay. If the ear is placed against the flank of a horse with an attack of colic the intestinal rumblings are found to be weak or even absent, while the flanks if slapped gently with the flat of the hand produce a drumlike sound.

The cause of flatulent colic is indigestion which is incited by giving tired and hungry horses a full meal of corn, meal, etc., upon returning from work. It may be produced by the animal gorging on succulent green food or by getting loose in the stable and raiding the oat-bin.

When flatulent colic is complicated by gas formation in the stomach the situation is critical, as, owing to the anatomical construction of the horse's gullet and stomach, the animal is unable to vomit or belch up the wind. In addition, the greatly distended stomach presses on the portion of the intestine leading from it (the duodenum) and locks the exit. Thus, unless the condition is relieved quickly, the stomach may burst with fatal results. The prominent symptoms of this condition are arching of the neck, opening of the mouth and futile attempts at vomition; an anxious expression and distressed breathing. Sometimes vomition does occur with the expulsion of food and gas through the nostrils at the moment when the stomach gives way.

It is seldom that the above condition (gastric tympany) can be relieved by drugs, and really the only effective treatment is the passing of a stomach tube up a nostril, down over the throat and into the stomach to liberate the gas. After this has been done medicines may be pumped into the stomach to prevent the further formation of gas both in the stomach and in the intestine.

Treatment—While veterinary surgeons have at their disposal certain drugs which will increase, or inhibit, the movements of the intestines as indicated by the condition of the patient, it is advisable to have on hand a colic drench containing chloral hydrate for spasmodic colic, and turpentine and linseed oil for the first-aid treatment of flatulent colic. In addition, in flatulent colic copious rectal injections of warm soapy water are also useful in stimulating the action of the lower bowel and the expulsion of the gas.

Lymphangitis, Monday Morning Leg, Big Leg, etc.—This is a disease peculiar to the heavy breeds of horses of what is known as the "lymphatic temperament." It occurs chiefly after a horse in hard work and heavy feeding is given a day's rest in the stable and is fed as usual.

Symptoms—The horse appears in great pain and may sweat profusely. One hind limb, or very exceptionally a fore limb, is found to be very greatly swollen, hot and tender to the touch and little or no weight is placed upon it. Pressure high up on the inside of the thigh causes the horse to lift the leg and carry it outwards, this action frequently being accompanied by a grunt or groan. The temperature is found to be very high and the pulse rapid and full.

Treatment—A full dose of a purgative medicine—veterinary surgeons use a quickly acting drug given hypodermically—followed by diuretics in order to ensure full action of the kidneys, such as potassium nitrate dissolved in water to drink, which should be allowed *ad lib*. Hot fomentations to the affected limb give relief to pain and help the absorption of the effusion, and the old-time practice of putting it into an old trouser leg or wrapping it in a straw band from the hoof upwards is not to be despised. The acute symptoms usually subside after the purgative has acted ; the pain and swelling become less although the swelling may take some time to subside, and in bad cases may not do so entirely.

It is not clear whether one attack predisposes to another or whether subsequent attacks are simply a constitutional matter, but it is a fact that each succeeding attack leaves the limb a little larger than it was before and the swollen condition of the limb becomes chronic. Any attempt to reduce the swelling by liniments, massage or irritant dressings not only end in failure but may even aggravate the condition. The diet during an attack should consist only of sloppy bran mashes, green food and hay. Hard worked and highly fed horses when given a rest in the stable should have their corn ration reduced to a third, or better still, be given only bran mashes and hay. A a further precaution, a tablespoonful of potassium nitrat may be dissolved in the drinking water.

Strangles—This is a contagious disease affecting young horse chiefly, although occasional cases occur amongst old animals. It is characterised by a rise of temperature, cough, and discharg from the nostrils and later by the swelling up and suppuratio of the lymphatic glands situated between the branches of th lower jaw. Appetite is impaired, or absent, thirst is increase on account of the fever, and it is quite evident from the wa in which the horse takes its food that it is suffering from a sor throat. In certain cases abscess formation does not remai localised in the glands beneath the jaw, and abscesses m form in any part, or any organ, of the body with fatal resul in the so-called "bastard strangles."

Treatment—The affected subject should be isolated, preferab in an airy loose-box, fed lightly on sloppy food and gree stuff and be allowed water to drink *ad lib*. A diuretic such potassium nitrate may be added to the drinking water f as long as the fever remains high and steaming the notrils w help to promote the free flow of mucous from them. Swoll glands may be either poulticed with a bran and linseed poultice, or, better still, with a compress of hot antiphlogistine (cataplasma kaolini B.P.) in order to localise the infection and accelerate the maturing of the abscess which should be freely lanced when ripe. After the evacuation of the pus the fever usually drops, the animal becomes convalescent but should be kept off all work for at least a month even when taking food quite freely.

Joint Ill in Foals—This is a disease of "buildings" and, unless the premises and foaling boxes, etc., are thoroughly cleaned out and disinfected upon each occasion, the disease is likely to appear year after year. It is quite rare amongst foals dropped in fresh green pastures. It is caused by the pus-producing germs entering the system by way of the navel, either at the time of birth or very shortly afterwards. It is contended that foals may be infected before birth.

Symptoms—In some cases foals may die a few days after birth from an acute infection, but usually the disease declares itself by the swelling up of one or more joints, knee, hock, or the stifle. An abscess is also sometimes present at the navel and the foal appears to be unthrifty. It is very lame, in time becomes unable to rise and lies prone. It rapidly loses condition and dies.

Treatment—Before the advent of penicillin and the sulphonamides treatment was hopeless and the few cases that did survive were crippled. Modern treatment—which can only be carried out by a veterinary surgeon—consists of the aspiration of the pus from an infected joint or an abscess in its close vicinity and massive doses of penicillin and one or other of the sulphonamides. It is very important, therefore, when any suspicion of joint ill arises for a veterinary surgeon to be called in with the least possible delay. On farms where outbreaks of this trouble are common, it is advisable to have the mares inoculated to pass on more or less immunity to their offspring. In addition to this attempt at prevention, the mare should be foaled down in a freshly cleaned and disinfected box and the navel cord of the foal should be ligated and disinfected as soon as it is born. It may also be given a dose of a polyvalent anti-serum.

Sore Backs and Collar Galls—Sore shoulders, collar galls and sore backs are caused either by friction or pressure, and are invariably the result of badly fitting or ill-adjusted harness or saddles. Young horses freshly up from grass when first put into the collar may have their shoulders "scalded" by the sweat and the working of the collar on a tender and unhardened skin.

Collar galls may be the result of pressure or friction, the latter occurring when the collar is too long and rocks on the top of the neck instead of remaining practically immovable on the shoulders. The neck may also be badly galled. Pressure galls may be caused by lumpy or uneven stuffing in a collar giving rise to points of pressure. The maladjustment of the draft which may be either too high or too low, or if the collar is fitted badly there may be a combination of friction and pressure. Saddle galls are nearly always due to pressure from a lumpy and badly stuffed saddle and serious injuries to the bones of the withers may be inflicted if any pressure at all is placed upon them. It is a fundamental principle in saddle fitting, whether a riding saddle or a cart harness pad, that no pressure whatever must come upon the middle line of the back, but only on the back muscles covering the spring of the ribs. This is the only place fit to take the weight.

The result of a saddle gall from pressure may be what is called a "sit-fast" in which there is a centre of dead skin surrounded by a sore, and for which the only successful treatment is the removal of the dead island of skin by surgical means. Girth galls which occur just behind the point of the elbow are common in young "green" horses with "grass bellies," and are more likely to occur if the wrinkles of the skin, which occur when the girths are tightened, are not smoothed out. They may to a large extent be prevented by slipping the girth through a portion of an inner tube of a motor tyre as this presents a smooth surface which becomes lubricated with sweat and does not cut like the edge of the girth.

Treatment—Unless it is possible for the saddler so to hollow out or channel the stuffing of the collar or saddle that no pressure comes upon a pressure gall there is no alternative but to rest the animal until healing takes place, and, of course, as regards an ill-fitting collar giving rise to friction sores the only alternative is to have it made to fit or to provide a new collar which does. At all times the face of the collar must be kept clean and free from caked sweat and dirt. The skin of the shoulders of "green" horses may be hardened by bathing them with cold salt and water with which the sweat after work should be washed off and by dabbing or spraying them with surgical spirit or methylated spirit.

The actual sores may be dabbed several times a day with white lotion, i.e. :—

Sulphate of zinc	¾-oz.
Sugar of lead	1 oz.
Water	1 pint

Should an abscess form, or a lump develop on the site of a pressure gall, the job becomes one for a veterinary surgeon to deal with. If the horse is being rested the sores may be rubbed with zinc ointment after the lotion has dried them up but not otherwise because if the horse is worked the friction on the ointment will give rise to a loss of hair.

Debility—Debility is an enfeebled state of the body whereby an animal is unable to do a normal day's work without becoming exhausted.

The signs are lack of ambition, wasted muscles, a capricious appetite—sometimes voracious, sometimes impaired. The eyes are sunken and the hollows of both the eyebrows become deeply pitted owing to the absorption of the orbital fat. The heart's action becomes weak and the rate of respiration is increased on exertion. Swellings may develop on the dependent parts of the body and the subject becomes hide-bound. The general appearance is one of dejection and misery.

Causes—The causes of debility are numerous and varied. It may occur in both aged and young animals from starvation, as a sequel to some debilitating disease, to parasitic infestations, and last, but not least, from dental irregularities. Horses in extreme old age become debilitated simply as the result of "senile decay," and general "wear-out," and for such cases little or nothing can be done although as a general principle other possible causes should be sought for and removed.

Treatment—Treatment depends upon the cause and it should be a rule to examine throughly mouth and teeth, especially the back ones, especially if a horse mumbles at its food and appears to have difficulty in masticating it, dropping quids of hay or boluses of partially chewed up corn out of the mouth. In young horses the trouble may be due to congestion and soreness of the gums from teething, or to the failure of "milk" teeth to fall out as the permanent ones are erupted thus remaining as "caps" on the top of the permanent teeth. The remedy is the removal of "caps" or loose milk teeth and the swabbing out of the mouth with a mild mouth wash, such as a teaspoonful each of powdered alum and tincture of myrrh in a pint of water followed by feeding soft food for a short time. In older horses the trouble is usually due to the outside edge of the upper back teeth and the inside edge of the lower ones becoming sharp and irregular and wounding the cheeks or the tongue. This is due to the lateral grinding action of the teeth which are composed of soft and very hard material (enamel). Careful rasping off of sharp projections and the razorlike edges of the teeth brings relief but upon no account must the table, or grinding surface, of the teeth be interfered with or the horse will be unable to grind its food. In other cases trouble may be due to a loose or ulcerated tooth, or to a molar tooth having grown above the level of the dental arcade. A horse's teeth grow continuously and if a tooth is lost from any cause the one opposing it in the other jaw continues to grow and may even attain a length sufficient to wound the gum of the vacant socket. These latter dental irregularities need attention from a veterinary surgeon.

In foals and young horses, sometimes in mature animals, worm infestations may be the cause of debility. Of these parasites the strongyle worms and the little red worms are the most pernicious, but their presence is usually accompanied by scouring and an anæmic condition in addition to loss of flesh and strength. Unless dealt with promptly and adequately death from exhaustion may result.

In addition to the discovery and removal of the cause o debility the subjects need careful feeding on highly nutritiou and easily digested foods, good housing, grooming an graduated exercise and a course of digestive and nerve tonics

Itchy Legs and Cracked Heels—A common trouble wit heavy horses is itchy legs. This is most often due to ski parasites although there may be considerable irritation in connection with " grease " or even " cracked heels."

When the trouble is due to the leg mange parasites or mite it seldom extends higher up than above the hocks or knee as the case may be. In extreme cases the mites have bee found on the thighs and even on the belly. The presenc of these mites crawling and feeding on the skin of the le causes great irritation which the animal endeavours to allevia by stamping and rubbing and perhaps by gnawing. The resu may be loosening, or even casting, of the shoes and injuri to the feet. Loss of hair from the legs will give a moth-cate appearance or the production of sores. An affected anim is often very difficult to shoe, frequently resents the handli of the legs or feet and may kick at anything which touches ther In extreme cases a horse becomes positively dangerous.

Treatment—Treatment is by no means difficult, the mit being easily destroyed. The main difficulty is to bring t dressings in contact with the mites on account of the ha It is advisable to clip the hair from the hooves to just above t hocks or knees as the case may be, and then, having render the skin quite clean with hot water and soap, they may dressed, or sprayed, with a 1 per cent. watery suspension benzene hexachloride. A second treatment seven days later needed. Alternatively the legs may be dressed with

Sublimed sulphur	4 parts
Oil of tar	2 ,,
Linseed oil	20 ,,

In the case of "grease" which may be recognised by the foul smelling discharge issuing from the skin or sores and the formation of "grapes," the treatment should be carried out by a veterinary surgeon who has remedies not available to the lay public. The disease may be kept in check by dressing two or three times a day with a lotion made by dissolving 3 oz. each sulphate of zinc, sulphate of copper and alum in a gallon of water.

The irritation is not so intense in the case of cracked heels which are due to chapping, cracking or fissuring of the skin in the bend of the heel. The practice of washing a horse's legs in soap and water is conducive to this trouble since it removes nature's protective oily secretion of the parts which prevents chapping and keeps the skin supple and pliable. In the first instance the parts may be swollen, hot and tender; later cracks of the skin appear from which issues an oily discharge which may become purulent. There may be considerable lameness.

Treatment—A poultice or an antiphlogistine application for 24 to 48 hours is useful for alleviating the primary inflammation and irritation. This should then be followed by dabbing the parts three or four times a day with white lotion:

Sugar of lead	1 oz.
Sulphate of zinc	1 oz.
Water	1 pint

until the discharge from the fissures ceases when the healing may be completed by rubbing in ordinary zinc ointment two or three times a day. In wet weather, if the horse *must* be worked, an alternative treatment is dressing the parts with:—

Liquor plumbi subacetatis forte	1 part
Olive oil	19 parts

On no account should the parts be washed with soap and water.

Broken Wind—This may be recognised by a double lift of the flank during expiration, and the condition is usually accompanied by a cough, or in severe cases, by chronic bronchitis with some nasal discharge. It is perhaps most frequently found in the case of fat horses and greedy feeders. The respiratory distress is due to a spasm of the muscles of the air cells of the lungs or even to their rupture. Whilst the intake of air is accomplished without difficulty the air can only be expelled by increased muscular action. In some few cases the cause may be overwork and the feeding of too bulky foods, but the primary cause may be traced to the stomach and the feeding of musty fodder, more especially badly saved and kept clover hay. There is no cure, but the subject may be kept capable of doing moderate work if fed little and often on concentrated feeds well moistened before being fed. Long hay should only be fed at night, the remaining portion of the daily hay ration being fed as chaff mixed with corn. Since many cases eat their bedding the latter is best composed of peat moss litter, or, if straw must be used, the horse should be kept muzzled between feeds.

TABLE 132—INCUBATION OR LATENCY OF DISEASE

Abortion, infectious, of cattle	126 days (average of 10 experiments).
,, ,, of mares	10 days to 3 weeks.
,, ,, of sheep	13–113 days.
Acne, contagious, of horse ...	3–14 days.
Anthrax	12–24 hours or more.
Avian plague	3–5 days.
Black quarter	1–5 days.
Braxy	About 48 hours (subcut. inocul.), 4 days (per os).
Cattle plague	4–5 days.
Distemper, canine	3–4 days to 3 weeks.
,, feline	4 days to 3 weeks.
Dourine	15–20 days (after coitus).
East coast fever...	10–20 days.
Erysipelas	3–7 days.
,, swine	2–3 days.
Foot and mouth disease ...	12 hours to 12 days.
Foot rot, contagious	3–6 days.
Fowl cholera	4–21 days.
Glanders or Farcy	1–6 weeks or more.
Heart water	11–18 days (after tick infection).
Influenza, equine	3–10 days (not definitely ascertained).
Leucocythæmia, infectious, of birds.	1–8 weeks or longer.
Louping ill	4 days (per os).
Lymphangitis, epizootic ...	8 days to 9 months.
Mammitis, acute	1–2 days.
,, chronic	May extend over some months.
Mammitis, subacute (catarrhal) and parenchymatous)	2–3 days to 2–3 months.
Mammitis, subacute (interstitial)	2–7 days.

Mediterranean fever	3–4 weeks (feeding experiments).
Milk sickness	2–12 days.
Nagana	2–3 weeks.
Piroplasmosis, bovine, British	4–12 days (after direct inoculation) ; 14 days at earliest, natural infection.
,, equine	Up to 3 weeks (from tick bites).
Pleuro-pneumonia, bovine ...	3 weeks to 3 months or more.
Pneumonia, contagious, equine	3–10 days.
Pneumo-pericarditis, epizootic, of turkeys	4–21 days.
Psittacosis	3–4 days to 3–4 weeks.
Rabies	10 days to 6 months.
Septic fever of cage birds ...	A few hours to 3 weeks.
South African horse sickness...	6–8 days.
Spirochætosis of fowls ...	2 or more days.
Strangles	3–8 days.
Surra	5–30 days.
Swine fever	5–15 days (average).
Tetanus, horse	4–15 days to 2–3 weeks.
,, cattle	5–8 days.
Texas fever	6 weeks (when brought to clean farm by infected ticks).
Tuberculosis	2 weeks to 2 month or more.
Typhus, canine	3–7 days (not definitely ascertained).
Vaginitis, contagious, granular, bovine	2–6 days.
Variola, caprina	1–7 days.
,, equina	6–8 days.
,, ovina	4–20 days.
,, vaccina	6–9 days.
Vesicular exanthema of bovines	1–10 days.
,, ,, horses	12–24 hours to 3–6 days.

DISEASES OF POULTRY

The disease problem has been more serious in the past in poultry than in other forms of livestock, mainly because of the rapid expansion in the industry and its extremely intensive nature. If an infectious disease does occur, therefore, it tends to spread with great rapidity, losses are severe and it is difficult to effect an economical control.

Diseases of poultry, like those of other animals, can be divided into two main groups :—

1. Specific diseases, caused by a distinct or specific parasite, germ or virus and which are infectious or contagious.

2. Non-specific diseases which occur either as constitutional disturbances of individual birds, or may be due to some factor in management, nutrition or breeding.

1. **Specific Diseases** Divisible into bacterial, virus, protozoan, internal or external parasites.

BACTERIAL (i) *B.W.D.* (Pullorum disease) caused by a bacterium of the salmonella group (S. pullorum) probably the most serious cause of mortality in young chicks. It may give rise to losses of from 20–80 per cent. Symptoms are not characteristic, and infected chicks may simply be found dead or dying within a few hours of showing lack of appetite, ruffed feathers, and sleepiness. Diarrhoea may or may not be present. Post-mortem lesions are inconsistent and specimens should always be sent to a veterinary laboratory for diagnosis. Chicks which survive an outbreak become carriers, the organism usually being found in the ovary. When these carriers mature, some of their eggs will contain the germ. During incubation the germs multiply with rapidity and when the resultant chicks hatch out they are virtually bathed in a suspension of the germs. As the chicks "dry off," infected down spreads through the incubator by the air currents and infects large numbers of further chicks as they hatch. In turn these infected chicks transmit the disease to other chicks by contamination of food and water while in the brooder house. Affected hatches are best destroyed and survivors should never be used for breeding.

Treatment with certain "sulpha" drugs is effective but such survivors may become carriers and should be retained only for egg production or as table birds. Control depends on the removal of carriers from the breeding flock by blood testing. This means taking a sample from the wing vein and sending the tube to a laboratory, or by using the rapid method which can be carried out on the farm. Under the P.S.I.P. testing is carried out by the rapid method free of charge. Details can be obtained from any veterinary laboratory, from a veterinary surgeon or Poultry Advisory Officer.

After removal of carriers, disinfection should be carried out and the remaining birds retested at monthly intervals until no further carriers are found. Control of the disease in incubators and the brooder house will be dealt with under the section on hygiene.

(ii) *Salmonellosis*—This term is used to describe outbreaks of disease in chicks caused by organisms of the salmonella group other than B.W.D. Some 30 organisms in this group are known to cause disease in chicks in this country.

The course of the disease is similar to that already described for B.W.D. Survivors again remain as carriers, usually harbouring the organism in the bowel wall, eggs laid by these carriers become contaminated on the outside of the shell with infected droppings and under incubator conditions the organisms penetrate the shell and infect the embryo. From then on the disease spreads in the same way as B.W.D. A measure of control can be obtained by collecting eggs frequently, using clean nest box litter and good egg storage conditions, etc. Dirty eggs should be dry-cleaned or dipped in germicidal solutions. Vermin are carriers of this disease so that every effort should be made to control vermin and to keep food in vermin-proof containers. Some outbreaks originate from the use of contaminated dried egg.

All affected hatches should be destroyed, although successful treatment has been reported with the use of "sulpha" drugs. In view of the large number of organisms which may be responsible, routine blood testing is not generally effective. In certain selected cases where the organism has been definitely identified, special testing can be carried out.

(iii) *Fowl typhoid*, is caused by *S. gallinarum*. This disease differs from the first two in that losses usually occur in mature birds. The disease is commonest in Wales, S.W. England and the bordering counties and is mostly seen on unhygienic farms. The mortality rate may be as high as 70 or 80 per cent.

Individual birds show lack of appetite, profuse yellowish diarrhoea, paleness of the head and die within 48 hours of first appearing ill. On post-mortem examination the liver will be found to be bronze-green in colour and the lungs congested and dirty brown. Treatment with "sulpha" drugs is said to be effective, but the disease is best controlled by the slaughter of sick birds and the burning or burial of dead or killed birds. Houses and equipment should be thoroughly disinfected and the healthy birds moved to clean ground. Blood testing should then be carried out carriers removed from the flock and the remaining birds vaccinated. The blood test for B.W.D. is equally effective for this disease ; the vaccine can be obtained from the Ministry of Agriculture's Veterinary Laboratory, Weybridge, Surrey.

(iv) *Tuberculosis* is caused by the avian strain of the tubercle bacillus, which is also responsible for tuberculosis in pigs. For this reason, pigs and poultry should not be kept in close contact. Cattle can also become infected with the avian strain but the disease is not progressive, although it may give rise to doubtful reactions to the tuberculin test in cattle. Infection occurs from the ingestion of food and water contaminated with droppings of infected birds. As in other animals, the disease is chronic and may be well established before symptoms are seen. Infected birds usually become emaciated, paleness of the head is common and there is frequently lameness of one leg. On post-mortem examination tubercles are found in the liver, spleen, intestines and bone marrow. No treatment is of value and it is usually most economical to slaughter the affected pens, burn or bury the carcases and carry out thorough disinfection. With valuable flocks infected birds can be detected by means of the tuberculin test which is carried out by injecting tuberculin into the wattle.

(v) *Fowl Cholera* is a highly infectious fatal disease, which may cause losses of up to 100 per cent. It is caused by a bacterium *Pasteurella avisepticus*. The disease is not common in this country and outbreaks usually result from the importation of infected poultry from abroad. The disease is usually rapid and few symptoms are observed. Birds are dull and the head parts congested and purple in colour. There is a profuse green diarrhoea. Post-mortem examination is inconclusive and requires bacteriological confirmation.

There is no treatment of known value and infected birds should be slaughtered and carcases burned or buried and disinfection carried out. A chronic form of the disease occasionally occurs in this country in which the only obvious symptom s a swelling of the wattles. Mortality with this type is low.

(vi) *Infectious arthritis*—This disease is sometimes seen in young stock causing lameness with hock-joint swelling. It results from infection with staphylococcal germs in small wounds of the feet and legs, usually caused by wire, thistles, glass, etc. Removal of the birds to fresh pens and thorough disinfection esults in the condition clearing up.

(vii) *Infectious coryza* (Contagious catarrh)—One form o his very common disease is caused by the bacterium *Haemophilu gallinarum*. Outbreaks vary in their severity and although losses are usually few, there is frequently severe interference with growth and egg production. Infected birds usually show discharge from nostrils and eyes which dries up in the form o crusts. Eventually thick cheesy material gathers in the sinuse of the head causing them to become swollen. The conditio is most prevalent when ventilation is poor or where there i over-crowding, malnutrition and other debilitating conditions Infection does not appear to produce immunity and survivor are frequently carriers and set up further outbreaks.

Prevention consists of improvements in management an hygiene and an adequate supply of vitamin A should be fe Affected birds should be isolated and disinfection carried ou Sulphonamide drugs, e.g., sulphathiazole and sulphamezathin are found to be effective against this type of coryza. Th addition of disinfectants to the drinking water, such as Lugol Iodine at the rate of one teaspoonful per gallon helps to preve the spread of infection.

VIRUS DISEASES—Viruses are live infectious agents, so sma they pass through porcelain or other filters which will hol back the smallest bacteria. They cannot be seen by the ordina microscope and are, therefore, known as ultra-microscop or filter-passing viruses. Some of the most serious poult diseases fall under this heading.

(i) *Fowl Pox*, also known as chicken pox, avian diphtheria roup. This is a contagious disease which exists in two form The first type is shown by the occurrence of small wate blisters on the comb, wattles and round the eyes. In a fe days these blisters dry up into brownish crusts which eventual run together to form a large wart-like growth. The second ty is shown by the occurrence of yellow diphtheritic membran covering the tongue, sides and roof of the mouth, and thro

Infection is usually spread by contamination of small woun but over-crowding, insanitary conditions and external parasi all contribute to the rapid spread of the disease. Although large number of birds may become infected, the death r may not be high, but many of the affected birds may have be destroyed from loss of condition. One or both forms the disease may be present in the same bird or in the same flo Provided the disease is observed before many birds are affect the most economic procedure is to destroy affected birds, ca out thorough disinfection and vaccinate the healthy on Vaccination is carried out by brushing a drop or two of vaccine on to a small area of the thigh from which few feathers have been removed. If vaccination is successf the area will be markedly swollen in 4-5 days. After vaccinat 14 days must elapse before immunity is produced ; during time the birds must be protected from further infection. Immunity lasts for about 4-6 months.

Treatment can be carried out by removing the scabs with a sharp knife and treating the under-lying surface with iodine or acriflavine, but there is a danger that while treatment is being undertaken, infection will spread to other birds.

(ii) *Fowl Pest*—This is a collective term used for legislative purposes and includes the two diseases—Newcastle disease and fowl plague. These are the only two poultry diseases in Great Britain which must be notified by law and in which there is compulsory slaughter of all infected flocks.

Newcastle disease is usually an acute, highly infectious disease with a mortality rate often as high as 90–100 per cent. Recently, however, mild outbreaks of the disease have occurred in this and other countries. The present epidemic started in 1947 and originated from infected table poultry imported from Europe. The disease mainly occurs in fowls, but outbreaks have been reported in pigeons and turkeys; ducks and geese are fairly resistant but may be capable of spreading infection to in-contact stock. In acute outbreaks, death usually occurs within 2–3 days of the first appearance of symptoms of frothy yellow diarrhoea, purplish congestion of the head and comb and a high-pitched rattling cough. Nervous symptoms may occur with twitching of the head and limbs and twisting of the head backwards or downwards. Any owner suspecting this disease, must immediately notify the nearest police station. If the disease is confirmed, there is compulsory slaughter of all birds and compensation for the non-affected birds. Disinfection of the premises is then carried out under supervision.

There are a number of other restrictions and orders regarding the movement of poultry, boiling of swill, disinfection of crates and utensils, etc. Poultry farmers should make themselves acquainted with their obligations under the Fowl Pest Order, copies of which can be obtained from the nearest police station, or direct from the Ministry of Agriculture.

In view of the fact that the disease is compulsorily notifiable, there is little point in describing its other features. Many outbreaks result from birds having access to infected material such as swill, hotel waste, etc., containing offal of infected poultry. Under the Swill Boiling Order, all swill must be boiled before being fed to poultry.

(iii) *Infectious Laryngo Tracheitis*—This is also a highly infectious disease affecting the respiratory tract. Outbreaks mainly originate from carrier birds, i.e., birds which have recovered from a previous attack. Infection can also be carried on attendants' feet, clothes, etc., and on appliances. The disease usually occurs suddenly with symptoms of coughing and sneezing in which the bird extends its neck fully and makes a prolonged inspiration through the wide open beak. Breathing is accompanied by rattling and clots of blood may be coughed up and be seen on the walls of the house. The death rate may be as high as 80 per cent. On post-mortem examination, clots of blood or cheesy material may be seen obstructing the wind pipe. There is no known treatment and affected birds should be slaughtered and all contacts isolated. Thorough disinfection of the premises and utensils must be carried out.

Other virus diseases are known to occur but are relatively uncommon compared with those described.

PROTOZOAN DISEASES—(i) *Coccidiosis*—Probably the heaviest cause of loss in chick rearing, caused by a small parasite of the protozoan group known as a Coccidium. There are two main types of the disease ; the acute form (caecal coccidiosis) which occurs mainly in young chicks during the first few weeks of life causing severe losses, often as high as 50 per cent. of the affected hatch. The second type known as intestinal coccidiosis is more chronic and occurs in older chicks of 3–4 months of age. Losses are not so heavy but there is severe emaciation and loss of condition.

In the caecal form, death is due to acute hemorrhage into the caecal tubes. Affected chicks may pass blood or blood-stained droppings. On examination, the caecal tubes will be found filled with blood or blood clot. In the intestinal form there is a persistent diarrhoea due to chronic inflammation of the small intestine.

Coccidia occur in a wide range of animals but each animal has its own particular species of the parasite. For example, the coccidium of the rabbit does not affect the fowl and vice versa—in fact coccidia of the chicken are quite distinct from those causing disease in turkeys and geese. The coccidium has a complicated life history the most important factor being that the parasite cannot infect other birds immediately it is passed out in the droppings and must spend a certain part of its time on the ground outside the host. This period depends on certain conditions of warmth and moisture and may not be less than 48 hours. On the other hand, the parasite may remain alive outside the body for as long as 18 months and still be infective.

In controlling the disease, advantage is taken of this fact by preventing chicks from having access to infected droppings. This is done by thorough cleaning of the house, the use of wire floors, movable folds, etc. Damp litter should be avoided and improvement in ventilation often helps. Over-crowding is also dangerous. The most effective disinfectant for floors, houses and utensils is a 10 per cent. watery solution of household ammonia, but chicks should not be allowed back until the house is free from all traces of ammonia.

In recent years it has been found that " Sulpha " drugs are very effective in the treatment of this disease. In this country the most commonly used drug is Sulphamezathine, which is available in a solution ready for use by adding 1 oz. to each gallon of the drinking water. Treatment should not be carried on for longer than 3-5 days and chicks which have recovered will be immune to further infection by that type of the parasite.

(ii) *Blackhead*—This is probably the commonest cause of loss in turkeys. It is caused by a protozoan parasite *Histomona meleagridis*. The exact life history of the parasite is uncertain, but is probably associated with the cæcal worm of the fowl. The mortality rate in young turkeys is frequently high and the common symptoms are ruffing of the feathers, loss of appetite and a mustard yellow diarrhoea. On post-morten examination circular greenish-yellow areas are seen in the liver and the caecal tubes are thickened and ulcerated.

Prevention by hygiene is similar to that outlined for coccidiosis. Young poults should not be reared in contact with older birds or on ground used for other fowls. Various proprietary drugs are available which are said to be of value in the treatment of the disease.

FUNGI—(i) *Aspergillosis*—This is also known as brooder pneumonia and results from chicks inhaling spores of the fungus Aspergillus, which usually occurs in damp or mouldy litter or feeding stuffs. The chicks show symptoms of difficult breathing and on post-mortem cheesy white nodules are found in the lungs and air sacs. There is no known treatment of value. Infected chicks should be killed, thorough disinfection carried out and an attempt made to find and remove the offending material.

(ii) *Moniliasis*—This disease is mainly seen in young turkey oults and is caused by the fungus Candida which causes lcerated patches in the crop. Losses can be high and often ppear to be associated with vitamin deficiencies. The exact rigin of the fungus is obscure and at the moment no treatment known. Slaughter and disinfection is so far the most satisfactory method of control.

INTERNAL PARASITES—Most of the larger parasites which are ound in or on poultry are only harmful if their numbers are xcessive Damp, dirty and badly ventilated houses and mal-utrition all lead to the rapid multiplication of such parasites. wo types of worms infest poultry, round worms and tapeworms.

(1) The large round worm—*Ascaris lineata*—about 1½ in . in. long and greyish-white in colour is found in the small

intestines. Treatment is by carbon tetrachloride capsules 2 to 4 cc. per bird.

(2) The caecal worm—*Heterakis galli*. Small threadlike, greyish-white in colour, about ⅛ in. long and found in the caecal tubes. Treat with phenothiazine, ½–1 gramme per bird.

(3) The gizzard worm—*Amidostomum nodusolum*—occurs in goslings, causing ulceration and hæmorrhage of the gizzard wall and may be fatal. Hair-like, white and only ¼ in. long, the worm can only be seen with difficulty adhering to the gizzard wall. Treatment, carbon tetrachloride, 1–2 cc. per bird in capsule.

(4) Tapeworms. Two forms occur in fowls. The small tapeworm, *Davania proglottina*, occurs in the small intestine and is seen as small white specks. The larger tapeworm—*Railletina*—is also found in the small intestines. It is white and up to 3 in. to 4 in. long, showing many segments. Tapeworms are best controlled by the destruction of their intermediate hosts, slugs and snails, by copper sulphate spraying of the runs.

Heavy infestations with worms causes unthriftiness, stunted growth, diarrhoea and anæmia. Prevention mainly depends on improved hygiene, frequent removal of droppings and soiled litter, separate rearing ground for young chicks, use of movable folds, etc. Infected runs should be rested for as long as 1 months.

External Parasites.—As with "worms," heavy infestation usually result from bad management and cause loss of condition stunted growth and in older birds, a drop in egg production

The chicken flea is similar to that found in other animals an mainly attacks the lightly feathered parts, under the wings back of head, etc. Different species of lice are found i different parts of the body—head louse, body louse and win louse.

The commonest mite, is the "Red Mite"—*Dermanyss gallinae*—which feeds on the bird at night and may cause deat by anæmia. Another mite burrows under the skin and roo of the feathers causing inflammation of the skin and loss feathers. It causes the disease known as "deplum scabies." A third form burrows under the scales of the le causing them to become swollen and covered by a white chalk deposit and is called "scaley leg."

Treatment for external parasites can be carried out by dust the birds with powdered sodium fluoride, D.D.T., gammexa or similar parasiticides. Nicotine sulphate (40 per cen is effective when used as a perch paint. Control, howeve mainly depends on disinfecting the house. Perches, ne boxes, etc., where these parasites can hide and breed must movable and should be dismantled at regular intervals, cleaned, creosoted or dipped in a paraffin emulsion. The walls, floor and ceilings should be similarly treated when "spring cleaned." Lime washes or paints in which D.D.T. or gammexane are incorporated are also valuable. When the house can be made air-tight, gammexane smokes are effective.

NUTRITIONAL DISEASES—(i) *Vitamin A*—A deficiency of this vitamin will retard growth, and cause the condition known as Nutritional Roup. The eyes show a watery discharge which later becomes a white cheesy deposit in the eye sockets and in the nasal passages. The best sources of vitamin A are fish oils and green foods such as clover and pasture grasses. Vitamin A is rapidly lost on exposure to the air and if fish oils are being used as its source, they must be mixed in the mash not more than a few hours before use. Fish oils must be stored in air-tight containers.

(ii) *Vitamin B*—There are a number of vitamins within this group, and a deficiency of several of them cause disease in chicks. The condition known as "curl-toe paralysis" results from a deficiency of riboflavin. In affected chicks the toes are turned inwards and in severe cases chicks may walk on the upper surface of the toes. A deficiency of pantothenic acid (also part of the vitamin B complex) causes chick dermatitis. Small crusty scabs appear at the corners of the beak, and around the eyes. Yeast (3–5 per cent.), dried skim milk, or dried whey are the best sources of vitamin B.

(iii) *Vitamin D*—Lack of this vitamin gives rise to rickets. Affected chicks lose the use of their legs, become dejected and unthrifty. The legs bend, the ribs thicken and the beak becomes soft and rubbery. The addition of 1–1½ per cent. cod liver oil usually prevents or cures rickets, but it may also arise as a result of an unbalanced or inadequate supply of calcium and phosphorus in the ration. A lack of direct sunlight also causes rickets

(iv) *Vitamin E*—Deficiency of this vitamin causes the condition called "crazy chick disease." Affected chicks walk in circles, or backwards, twisting the head back over the body. A deficiency of this vitamin probably results from its destruction by some other constituent in the ration, e.g., rancid oil or excess of cod liver oil.

(v) *Perosis*—Is also known as "hock" disease or "slipped tendon" and is thought to be caused by a deficiency of the mineral manganese, probably associated with a deficiency of choline (vitamin B complex). In affected chicks the large tendons of the legs slip outwards from the hock joint. The leg becomes twisted and the chick walks on its hocks. The addition of 4 oz. of manganese sulphate per ton of food corrects the trouble.

UNCLASSIFIED DISEASES—(i) *The Fowl Paralysis Complex* (Avian Leukosis, Lymphomatosis)—This is undoubtedly the commonest single cause of loss in poultry and although the exact cause of this disease is obscure, most workers regard it as being infectious and consider it is caused by a virus or group of viruses. There are five forms of the disease recognised, although all result from the multiplication and accumulation of certain types of blood cells. The type of the disease and symptoms depends on the organ or tissue invaded by these cells.

1. True fowl paralysis—(Neurolymphomatosis)—The main nerves to the limbs, chest wall, neck and intestines, are commonly affected giving rise to lameness, dropped wing, twisted neck, impaction of the intestines, etc. Leg paralysis which is the commonest, is quite typical starting with a limp in one leg, followed by clutching of the foot and finally complete loss of the use of both legs. The bird being unable to get to food rapidly looses condition.

2. Visceral lymphomatosis—This is the commonest form of the disease. It occurs usually as multiple white soft tumour growths of the liver, spleen, kidneys, ovary, heart and other organs. The liver is most commonly affected, often being enlarged to four times its normal size—" Big Liver Disease."

3. Ocular lymphomatosis—In this type cells invade the iris of the eye. The normal colour fades to become bluish-grey and opaque (" fish eye "). The pupil loses its normally circular shapes, becomes irregular, elongated and slit-like and incapable of contraction and dilatation.

4. Osteopetrosis (Marble bone)—An uncommon form of the disease in which the long bones, mainly the shanks, become distorted, thickened and like stone.

5. Leukæmia—In this type the blood and blood forming organs are involved, the liver and spleen often being grossly enlarged and the bird anæmic.

More than one form may occur in the same bird and in the same flock. It is thought that infection is mainly transmitted during the first few weeks of life and that the first ten days or so are the most dangerous. Certain factors such as parasites, nutritional deficiency, or even bacteria, may predispose to this disease. When chicks are reared in isolation from possible infection, particularly from infected adults, there is a good chance of controlling the disease. It is doubtful whether the disease is egg transmitted. Evidence also shows different strains of birds to vary in their susceptibility to the disease. Such genetical differences among families when properly handled, can be used to reduce losses. This is done by two methods, either mass selection, or by progeny testing. In mass selection only yearlings or older birds are used for breeding. The most susceptible birds will have been eliminated and the survivors should transmit some of their resistance to their offspring. Resistant birds can be developed farther and faster by progeny testing, from the least susceptible families. This involves the retention of infection in the flock so that the progeny can be tested for resistance—a risk which few breeders may care to undertake.

There is no known treatment of any value for lymphomatosis.

(ii) *Pullet Disease* (or Blue Comb)—Although well known in other countries, this disease has only been reported in Great Britain during the last few years, since when it has become of considerable importance. It is an acute disease and usually a large number of birds in a flock become affected at the same time. There is sudden loss of appetite accompanied by whitish diarrhoea and the combs may turn dark blue or purple. The most striking feature is a sudden drop in egg production, sometimes in pullet flocks from 50 per cent. to nil in a few days. Affected birds show a tendency to eat coarse grass or bedding, often leading to crop-binding. As a rule only a few birds die, although there may be a number of culls. The remainder recover spontaneously two or three weeks later.

The disease results from a breakdown of the kidneys and birds which die show disease of the kidneys (nephritis) with deposits of urates on the heart, liver and spleen. This latter condition is known as visceral gout.

The cause of this disease is obscure, and although outbreaks frequently coincide with changes in the feeding, there is no evidence that any ingredient or foodstuff as such can set up the disease. Some workers claim that new wheat is responsible—this theory has found little support. In some respects the disease would appear to be infectious but no infectious agent can be incriminated. In view of our lack of knowledge as to the cause of the disease, no definite treatment can be recommended. Keeping the flock intensively for a few days or restricted to the house helps to prevent crop binding. Mild laxatives such as Epsom or Glauber salts can be given and it has been suggested that the addition of 10 per cent. molasses or other readily available carbohydrate to a wet mash is helpful. One American worker recommends the addition of 0·5 per cent. potassium chloride to the drinking water. Good results have also been claimed for copper sulphate at the rate of 1 part in 2,000 in the drinking water.

MISCELLANEOUS DISEASES—(i) *Cannibalism and feather pecking*—Both these conditions are aften associated with some factor in the management, such as overcrowding, lack of trough space, or may even be of nutritional origin, e.g., a deficiency of protein. Once started the condition rapidly becomes a " vice " copied by other birds which are attracted to pecked or bleeding surfaces. Some workers claim that the vice can be treated by increasing the salt content of the diet to 2–2½ per cent. for a few days. The vice can be controlled by " debeaking," e.g., removing the point of the upper beak " Spectacles," a device which fits through the nostrils and only permits the bird to look downwards are the most effective control. Injured or pecked birds which invite cannibalism should be isolated immediately and the area dressed with deterrent such as Stockholm tar.

(ii) *Impaction of the Crop*—This may occur as a symptom i a number of diseases, such as fowl paralysis or pullet disease but more frequently results from a mechanical cause such a access to long grass, straw. feathers, etc., or consumption o large quantities of bulky foods. It can often be treated b holding the bird head downwards. " kneading " the crop an removing the contents through the beak. Early cases respon to flushing out the crop with water. In advanced impaction surgical removal of the contents through the crop wall ma be required. In large flocks single cases are usually culled an treatment is uneconomical. When several birds becom affected the diet and management should be investigated, an the grass in the runs kept short.

(iii) *Vent gleet*—This is thought to be a contagious diseas spread at mating or by contact with infected nest box litte etc. It starts with soiled feathers round the vent and the sk of that region is inflamed, swollen and often shows chees white, evil smelling, deposits. A number of birds may affected with a consequent drop in egg production. Can balism may result. Advanced cases should be destroyed a early cases isolated, particular search being made for affect males. The affected part can be treated by swabbing wi antiseptic lotions, the cheesy deposits removed and the surfa dusted with sulphonilamide powder.

(iv) *Bumblefoot*—Is an abscess in the region of the fo usually resulting from small wounds caused by glass, wire, sm stones, and which become infected with bacteria. The fo becomes obviously swollen, hot and painful and the infecti may extend up the shank tendons causing severe lamene Usually surgical incision of the abscess and removal of t solid pus is necessary. The wound is then packed with gau soaked or impregnated with an antiseptic and a dressing applie Except in valuable birds, treatment is uneconomical.

(v) *Egg peritonitis*—This is one of the commonest conditio met with in the post-mortem examination of poultry. It oft results from " internal laying," the yolks passing direct into t abdominal cavity ; or as a sequel to " egg-binding." Carri of B.W.D. and fowl typhoid where there is infection of the ovary are often affected with egg peritonitis. Affected birds have a penguin-like appearance with a swollen abdomen. There is no cure.

(vi) *Egg binding*—This occurs when the oviduct becomes obstructed by a large broken, or mis-shapen egg, or by the accumulation of abnormal egg material in the oviduct. Affected birds repeatedly visit the nest without laying and will be seen to strain. Prolapse of the vent and oviduct may result, and may be followed by "cannibalism."

In some cases the impacting mass can be removed by inserting a finger through the vent and manipulating the abdomen.

(vii) *Poisoning* is common in poultry, usually as a result of accidental access to carelessly placed rat baits. The commonest are arsenic, phosphorus, and zinc phosphide. All cause sudden death and there is seldom an opportunity to use antidotes. Poisoning may result from the use of grossly excessive amounts of salt, in waste salted vegetables, kitchen waste, etc. Heavy losses have occurred from the use of cocoa waste products in substitute foods.

HYGIENE—Except in the case of the new intensive system, known as the deep or built-up litter method, all poultry houses must be regularly cleaned out and occasionally subjected to a thorough spring cleaning. Bacteria, viruses, worms and other parasites all multiply very rapidly in a dark, dirty and humid atmosphere. Houses should be well ventilated and lighted and so constructed that perches, nest boxes, etc., can be readily removed and do not permanently harbour dust, dirt and other debris. Dropping boards should be scraped daily and slatted floors similarly treated so that manure does not accumulate and interfere with ventilation. Nest box litter must be renewed at very frequent intervals. Many diseases are spread by infected food and water, and these containers should receive special attention. Water bowls should be rinsed out daily before refilling and where wet mash is used, the troughs require regular cleaning or food rapidly moulds.

Birds should never be moved to new accommodation until the houses and utensils have been cleaned and disinfected. Similarly, when houses are vacated, or when disease has occurred, they should be treated in the following manner. After removal of the birds, the litter, floors, walls and ceilings should be sprayed with an approved disinfectant in the recommended strength. This lays the dust and disinfects the bedding. The walls and floor are then scraped down and the scrapings and bedding removed (if disease has been present the waste should be incinerated) to the manure heap. The interior of the houses and all equipment must then be scrubbed with hot water containing 4 per cent. washing soda to remove the grease and dirt. After it has dried, the house should be finally sprayed with a disinfectant and left exposed to the air and sunlight for as long as possible. A 10 per cent. watery solution of household ammonia is the best agent for the destruction of coccidia, while for external parasites, D.D.T. or Gammexane should be used.

Incubators require special treatment and the most satisfactory method is fumigation with formaldehyde gas. The gas is liberated by placing potassium permanganate in a bowl and pouring commercial 40 per cent. formalin on top. The recommended amounts vary from 1 oz. potassium permanganate and 1½ oz. formalin for every 100 cubic feet of incubator space to as much as 3½ oz. permanganate and 5¼ oz. formalin for every 100 cubic feet. The most satisfactory results are obtained with the higher strengths but such strengths must not be used during the 24th to the 84th hours of incubation and never on live chicks. The ventilator ports should be kept open if there are hatching eggs in the machine and the gas should be allowed to operate for 30 minutes with the fan running. Movable parts, such as trays, should be scrubbed with hot water and washing soda and washed or sprayed with a solution of sodium hypochlorite. Fluff and dust can be removed by vacuum cleaner and together with the egg shells and other incubator debris burned or incinerated.

Little can be done to decontaminate infected ground, except to rest the runs for the longest available period—12 months if possible. Grass should be kept short to permit of the maximum exposure to the air and sunlight. Liming at the rate of two tons to the acre is said to be beneficial.

Where fixed houses are used, the soil immediately around the house should be removed to a depth of one spit, the exposed sub-soil sprayed with disinfectant and covered with layers of clinker and fine ashes.

A sick bird is the greatest source of danger to the rest of the flock and must be immediately isolated or culled. Dead birds should be buried or burned.

Newly purchased, or returned stock, should be isolated for 21 days before being mixed with the flock.

Discourage visitors from entering poultry houses or pens and prevent all poultry from gaining access to swill until it has been boiled. Eliminate vermin, keep your stock separate from older birds and buy stock only from a reputable source where controlled blood testing is practised.

Finally, seek qualified, authoritative advice if disease appear and seek it promptly.

DAIRYING

CONSTITUENTS OF MILK.

These are shown in the following diagram :

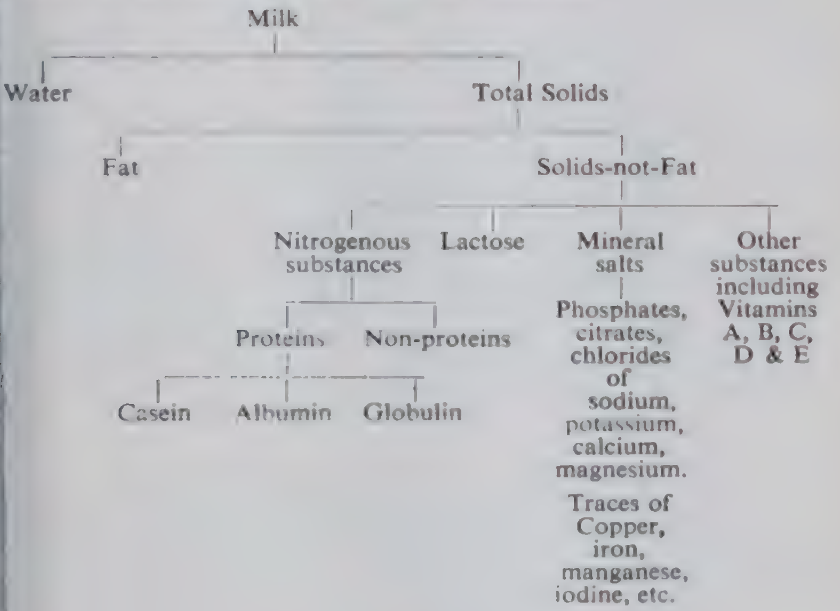

Milk
Water
Total Solids
Fat
Solids-not-Fat
Nitrogenous substances
Lactose
Mineral salts
Other substances including Vitamins A, B, C, D & E
Proteins
Non-proteins
Phosphates, citrates, chlorides of sodium, potassium, calcium, magnesium.
Traces of Copper, iron, manganese, iodine, etc.
Casein
Albumin
Globulin

Fig. 12

TABLE 133

AVERAGE COMPOSITION OF MILK

The following table is based on the reports of various worker
in Great Britain who have examined large numbers of samples

Author	Period	No. of Samples	Source	Average Percentag Composition		
				Water	Fat	Solids not-Fa
Richmond	1900–1920	330,000	Southern England	87·48	3·78	8·74
Baker & Cranfield	1923–1931	300,000	Midlands	87·48	3·61	8·91
Elsdon	1903–1934	771,000	England ...	87·62	3 61	8·7
Golding *et al.*	1930–1932	3,115	Southern England	87·22	3·89	8·8
Crowther	1904	4,220	Yorkshire	87·52	3·70	8·7
Tocher	1923	676	Scotland ...	87·27	3·95	8·7
Provan	1945–1949	200,000	England & Wales	87·73	3·60	8·6

Thus considerable variation may occur in " average co
position " of milk as reported by various workers. The larg
the bulk of milk, the more constant is the composition, b
even then there are wide variations which may occur due
breed, season of the year or district.

TABLE 134

VARIATIONS IN COMPOSITION OF MILK

The following variations have been reported by vario
authorities :

	Butter Fat Per cent.			Solids-not-Fat Per cent.		
	Maximum	Minimum	Average	Maximum	Minimum	Avera
Richmond ...	6·39	1·03	3·78	10 60	4·90	8·7
Crowther ...	5·30	2·00	3·70	9·50	8·40	8·7
Tocher ...	7·50	1·66	3·95	10 66	7·00	8·8
Golding *et al.*	5·17	2·60	3·88	9·28	8·40	8·

TABLE 135

SEASONAL VARIATIONS IN THE COMPOSITION OF MILK

MONTH	1897–1916			1945–1949		
	Buckinghamshire (Droop Richmond)			England and Wales (Milk Marketing Board Creameries)		
	Total Solids Per cent.	Butter-Fat Per cent.	Solids-not-Fat Per cent.	Total Solids Per cent.	Butter-Fat Per cent.	Solids-not-Fat Per cent.
January	12·75	3·79	8·96	12·31	3·64	8·67
February	12·67	3·72	8·95	12·22	3·57	8·65
March	12·62	3·67	8·95	12·13	3·51	8·62
April	12·54	3·65	8·89	12·09	3·47	8·62
May	12·50	3·56	8·94	12·12	3·39	8·73
June	12·42	3·52	8·90	12·21	3·44	8·77
July	12·39	3·63	8·76	12·23	3·52	8·71
August	12·51	3·76	8·75	12·26	3·57	8·69
September... ...	12·70	3·85	8·85	12·40	3·68	8·72
October	12·84	3·91	8·93	12·53	3·78	8·75
November... ...	12·94	3·98	8·96	12·53	3·81	8·72
December... ...	12·87	3·91	8·96	12·39	3·72	8·67

TABLE 136

AVERAGE COMPOSITION OF MILK (E.R. LING)

	Per cent.
Water	87·54
Fat	3·71
Nitrogenous substances	
Proteins—Casein	2·63
Albumin	0·31
Globulin	0·11
Non-Protein	0·24
Lactose	4·70
Ash	0·76
	100·00

TABLE 137

COMPOSITION OF MILK FROM VARIOUS MAMMALS

	Total Solids Per cent.	Fat Per cent.	Casein Per cent.	Other nitrogenous substances Per cent.	Lactose Per cent.	Ash Per cent.
Human ...	12·59	3·78	1·03	1·26	6·21	0·31
Cow	12·46	3·71	2·63	0·66	4·70	0·76
Ewe	19·18	6·86	4·97	1·55	4·91	0·87
Goat	14·29	4·78	3·20	1·09	4·46	0·76
Mare ...	9·30	1·20	1·90	0·10	5·70	0·40
Sow	15·96	4·55	7·23		3·13	1·05
Buffalo ...	18·59	7·47	5·85	0·25	4·15	0·87
Elephant ...	32·15	19·57	3·09		8·84	0·65

TABLE 138

COMPOSITION OF COLOSTRUM

	Total Solids Per cent.	Butter Fat Per cent.	Total Protein Per cent.	Lactose Per cent.	Ash Per cent.
First milking	24·55	3·89	16·76	2·50	1·33
Second milking ...	18·00	3·84	9·33	3·52	0·97
Third milking	16·79	3·11	7·06	3·85	0·96
Fourth milking ...	15·21	3·82	6·16	4·23	0·88

Average of Observations by 25 investigators. (Ling).

TABLE 139

COMPARATIVE YIELDS OF DIFFERENT BREEDS OF COWS—ENGLAND AND WALES*

Breed or Breed Type	Number of Herds	Average Yield of Milk lb.	Average Butter Fat Per cent.	Average Yield of Butter Fat lb.
Ayrshire	2,601	8,088	3·81	308
British White (Park) ...	8	6,714	3·79	254
Devon	24	5,953	4·18	249
Dexter	15	4,986	4·15	207
Friesian	4,752	9,141	3·45	315
Guernsey	1,393	7,473	4·56	341
Jersey	1,082	7,051	5·05	356
Kerry	10	7,203	3·88	279
Lincoln Red Shorthorn	71	7,487	3·58	268
Red Poll	425	7,476	3·60	269
Shorthorn	5,022	7,365	3·58	264
South Devon	300	6,738	4·26	287
Welsh Black	97	5,787	4·12	238
Mixed and others ...	3,418	7,602	3·72	283
TOTAL—All breeds	19,218	7,986	3·79	303

*National Milk Records—Annual Report, 1948–49

TABLE 140

COMPOSITION OF BULKED HERD MILK FROM DIFFERENT BREEDS—1945–1947

Breed	Average Composition as Received at Milk Marketing Board Creameries	
	Butter Fat Per cent.	Solids-not-Fat Per cent.
Channel Island	4·41	8·93
Ayrshire	3·72	8·73
Shorthorn	3·65	8·68
Friesian	3·45	8·58

TABLE 141

WEIGHTS OF SOLIDS IN ONE GALLON OF MILK

	12·5 per cent. Total Solids	14·0 per cent. Total Solids
	ozs.	ozs.
Butter Fat	5·74	7·79
Lactose	7·87	7·87
Albumin	0·66	0·66
Casein	5·08	5·41
Ash	1·15	1·23
	20·50	22·96

Relationship between various constituents

Fat and Solids-not-Fat—There is an average relationshi between these two fractions, but this may not apply to individua samples of bulked milk or milk from individual animals. As fa as breeding is concerned, there is evidence that butter fat an solids-not-fat contents are separately inherited characteristic

Lactose, Protein and Ash—Vieth gives the ratio between thes constituents for normal milk as 13 : 9 : 2. This ratio can b used as a test of adulteration, as addition of water will n affect the ratio while, with genuine milks of poor chemic composition, the ratio does not hold. There may be wi variations from the ratio with individual samples.

Chlorides and Lactose—There is an inverse relationsh between these constituents, a high chloride being associat with a low concentration of lactose and vice versa.

MILK CONSTITUENTS

Water—Water in milk exists as ordinary water, but cannot separated from the milk solids except by a chemical means by evaporation. It forms from 84 to 90 per cent. of the m by weight, but extreme figures are only obtained with sm bulks of milk such as those from individual cows.

Butter Fat—Butter fat exists as an emulsion of tiny drops globules suspended in the milk serum, the serum consisting o solution of lactose, protein and mineral substances. It is n acknowledged that there is no protein membrane surroundi each globule, but that the molecular force of the small globu is sufficient to give a thin watery covering of milk serum co stituents, giving the physical properties of a membrane. O pound of milk with a butter-fat content of 4 per cent. conta about 40,000 million fat globules. The largest fat globu in cream are 0·0005 to 0·0006 in. in diameter, and the smallest may be one-tenth of this. The size varies in different breeds, the largest butter-fat globules being present in Jersey milk and the smallest in Ayrshire and Friesian milk, the size of the fat globule diminishing from the time of calving. Large globules are most easily churned ; thus cream with :

Size of Globule	May be churned in.
0·000225 in.	13 minutes.
0·00019 in.	30 ,,
0·00018 in.	34 ,,

Large globules are best for butter-making—such as in Jersey milk—and small ones for cheese. The larger ones rise more rapidly into the cream and churn more readily, while the smaller ones may never rise, and tend to make an even textured cheese.

Proteins—Casein is the principal one and it is in colloidal solution in the form of a dilute jelly swelled up by absorption of water. It will not dialyse, but when curdled dissolves in dilute hydrochloric acid or sodium hydroxide.

Of the other proteins present, the principal one is albumin. Casein is coagulated by the addition of acids or rennet, but not by boiling. Albumin is not coagulated by rennet or most acids but by heat. Colostrum contains a high proportion of albumin, and therefore coagulates on boiling.

Lactose (Milk Sugar)—Lactose is the principal carbohydrate present in milk and is in true solution. It can be crystallised from whey by evaporation.

Ash—Ash consists of various salts partly in solution, of which calcium and potassium phosphates and sodium chloride predominate. Some calcium is loosely bound with the casein as calcium caseinate. The other minerals such as copper, manganese, magnesium, cobalt, are mostly in solution, but the quantities present are very small. The proportion of ash remains fairly constant in normal milks and, therefore, a decided reduction in this constituent may be an indication of added water.

Colouring Matters—Milk contains the yellow colouring matter carotene. It is present in greatest proportions during the summer and in milk from the Channel Island breeds and is responsible for the deeper yellow colour of the fat. The concentration is also higher in the colostrum of all breeds. This colouring matter is the same as that of plants and can be increased by feeding foods rich in carotene such as carrots or young spring grass. A water-soluble pigment—riboflavin—is responsible for the greenish colour in whey.

FACTORS INFLUENCING SECRETION AND CHEMICAL COMPOSITION OF MILK

Breed—The breeds of dairy cattle recognised in this country are Shorthorn and Lincoln Red Shorthorn, Friesian, Devon and South Devon, Red Poll, Ayrshire, Jersey, Guernsey, Kerry, Dexter, Welsh Black and British White. The comparative yields of each have been given in Table 139. The Channel Island breeds—Jersey and Guernsey—produce milk containing the highest proportion of fat and solids-not-fat, while the Friesian produces, on average, the poorest milk.

Temperament—An animal with a healthy, well-developed nervous system milks better than one with a sluggish, phlegmatic temperament, i.e., the most intelligent cow is the best milker. Such animals require very careful treatment or they degenerate into nervous, fidgety, easily frightened animals with reduced milk yields and tend to produce milk with widely fluctuating variations in composition, particularly in butter fat.

Health—Cows must be healthy to give high yields of good quality milk. The most serious troubles are tuberculosis and various ailments of the udder, such as mastitis, wounds, etc. Sheds must be sanitary, well lighted and well ventilated. Udder troubles can cause deterioration in the milk secreted, e.g., mastitis in the early stages may reduce the yield with an accompanying increase in butter fat and decrease in the solids-not-fat content. Serious infection may result in a milk which is deficient in fat and solids-not-fat.

Age—A cow in good health continues to improve in milking capacity up to her 7th or 8th lactation, and the yield remains high until the 10th or 12th lactation. The milk of heifers is richer in fat and solids-not-fat than in succeeding lactations.

Period of Lactation—The cow attains her highest yield about six to eight weeks after calving. The yield then declines and the cow naturally dries off about nine months after calving. The fat and solids-not-fat contents of milk decrease as the yield increases, so that fat and solids-not-fat contents are at their lowest during the period of maximum milk production. The only constituent of milk which is high in the period of maximum production is the lactose.

Period of the Year—The flush of young grass in early summer stimulates the milk yield of cows in whatever period of lactation they may be, while the dry, brown pastures and hot weather of summer depress the yield. There is a marked seasonal variation in both fat and solids-not-fat as shown on page 453 The butter fat is softer in summer than in winter, irrespective of temperature. This is due to an increase in olein content of the butter fat in the summer and of stearin in the winter.

Oestrus—The service heat has little effect on some cows, but in most cases the quantity of milk is reduced. This may be accompanied by quite large variations in the butter fat content of the milk which may be increased or decreased by one per cent. or more. There is little effect on the solids-not-fat content. These changes are temporary, lasting only two or three days, and disappear immediately the œstrus is over.

Food—Food largely influences the quantity of milk, but it can also influence the composition of the milk. Poor feeding results in low yields, a small decrease in butter-fat and, in many instances, a marked decrease in the solids-not-fat. The seasonal variation in solids-not-fat is partly due to poor nutrition during the winter months which results in a very low level of solids-not-fat in late winter. Similarly, the increase in solids-not-fat on turning out to spring pasture is probably due to the higher nutritive value of young spring grass as compared with winter rations, while summer grass of lower nutritive value is accompanied by a decrease in solids-not-fat. The presence of œstrogens—or milk stimulating substances—in early spring grass may be responsible for the increase in yield and improved composition of spring milk.

Proper feeding is important in maintaining both the yield and composition of milk and treatment prior to calving—steaming up—is essential. If a cow calves down in good condition, she has reserves of fat and flesh which can be utilised to provide for the period of maximum yield.

Feeding stuffs such as young oats or lush spring grass which are low in fibre and high in protein can cause a reduction in the butter fat content.

Soil—Although it is generally held that the nature of the soil influences the quality of the milk, presumably through pasture and other crops, there is no evidence to show that this is true. There are indications, however, that some fields are responsible for a lower fat content than others, and also that milk from limestone soils is less heat stable than that from other areas.

Water Supply—A plentiful supply of good water is essential in both summer and winter. According to the Geneva (N.Y.) experiments with seven different breeds, cows require about five gallons of water to every gallon of milk yielded, every 1 lb. of dry food requiring 3 to 4 lb. of water.

Temperature—Cows yield best when kept at a temperature of 40° to 50° F. This is often exceeded in summer, but in winter it is always possible to keep the air temperature of the cow houses up to this from the natural heat of the animals alone and, at the same time, have proper ventilation. Cows are more liable to take chills if, during winter, they are turned out for exercise from warm, badly ventilated sheds. Yields are reduced slightly by low temperatures and this is accompanied by an increase in butter-fat.

Exercise—A certain amount of exercise is beneficial. It has been stated that, as compared with cows at rest, the fat in milk may be 0·3 to 0·4 per cent. richer in cases of those animals getting exercise, while the total milk yield is maintaine or even improved.

Weather—A frost causes an immediate reduction in yiel which may be only temporary. A hot, dry period in summe has the same effect. Continuous dry, hot weather reduce the solids-not-fat, but increases the fat content. This is probabl bound up with the nutrition of the animal.

Treatment of the Animal—Gentle treatment is of utmos importance, as anything upsetting to the animal causes " hol up " of milk and eventually decreases the daily yield. Cow should never be worried and always handled quietly. Whe pestered by flies, the yield is adversely affected. Quick an clean milking increases both quantity and quality of milk while slow, slovenly work adversely affects both and cause premature "drying off." Inefficient milking may injure a animal to an extent that cannot be remedied. Babcock foun that quick milking compared with slow milking produced fro 2 to 13 per cent. more milk which was richer in fat, and th continued for several months until the normal lactation decline occurred. This has been confirmed by other worker Much of the variation of fat content is due to inefficient milker

Milking machines are increasing in popularity and, proper managed, are as efficient as hand milking and, in addition, a labour-saving, particularly in the larger herds. They may economical for herds of ten cows or less. Milking machin should be handled by skilled personnel, as much of the troub experienced with mastitis and other udder complaints on i stallation of a milking machine is caused by poor manageme They must not be left on too long or allowed to " creep." this injures the udder tissues. Machines must be proper cleaned and sterilised to prevent spread of mastitis and oth udder troubles and produce milk of good hygienic quali There is considerable difference of opinion as to whether ha stripping is necessary after the machine. General experien seems to indicate that it is unnecessary if the udder is massag before removing the machine.

Milking Intervals—There is a tendency for more milk co taining less fat to be given at the morning milking. T difference is least when the periods between milking are exac 12 hours and is accentuated when the night period beco longer than the day period.

There is little variation in the solids-not-fat content of milk, but there is a tendency for morning milk to be richer than evening. Where three times a day milking is practised, milk during the day is usually richer in fat than that obtained during the night periods, even when the milking periods are equal.

Stripping—The fat content of milk varies during milking, as shown in the following table :—

TABLE 142.

FAT CONTENT OF MILK DURING MILKING.

Portion.	Cow "A"	Cow "B"	Cow "C"
First ...	... 0·90	1·60	1·60
Second	... 2·60	3·20	3·25
Third ...	... 5·35	4·10	5·00
Strippings	... 9·80	8·10	8·30

The solids-not-fat content tends to fall as the fat increases.

From this it will be seen complete milking is necessary not only to obtain maximum yields, but also maximum butter-fat content.

Souring of Milk—Milk is an ideal medium for the growth of many organisms. These cause various chemical changes in the milk and are responsible for souring. The bacteria normally found in milk may be divided into two main groups :—

(*a*) Those producing lactic acid from lactose

and (*b*) Those which attack the protein and often produce bacterial rennet.

The main sources of these organisms are the surfaces of equipment, the cow, the milker and the air. Milk as it leaves the healthy cow contains very few organisms, but contamination may take place immediately after milking. Bacteria gain entry with dirt from the cow or any of the sources given above. The most serious source of contamination is, however, the surfaces of inefficiently cleaned utensils.

Normally, souring is brought about by the lactic acid producing bacteria. These convert the lactose into lactic acid which accumulates in the milk until, finally, sufficient is present to precipitate the casein and clot the milk. Souring occurs most rapidly at temperatures of 60° to 90° F., lactic acid producing bacteria growing best in this range. Milk with a titratable acidity of 0·20 to 0·25 per cent. lactic acid tastes sour, with an acidity of 0·3 per cent. clots on boiling, and with an acidity of 0·6 per cent. curdles spontaneously.

The organisms mainly responsible for lactic acid production are the lactic acid producing streptococci, e.g., *Streptococcus lactis* and the coliform organisms, the latter producing large quantities of carbon dioxide and hydrogen in addition to lactic acid. Sweet curdling may occur occasionally, and this is sometimes due to aerobic proteolytic spore-forming organisms.

To ensure that milk has a long life before souring, every precaution must be taken during the production to prevent contamination. This can only be done by paying attention to hygiene during production and handling. Milk should always be produced from clean, healthy cows, handled in clean, sterile utensils, and be cooled and kept cool until delivered to the consumer.

A very high proportion of the milk delivered to consumers is now heat-treated. The officially recognised methods of heat-treatment are :—

(*a*) *Pasteurisation* (1) The holder method in which the milk is held at 145° to 150° F. for at least 30 minutes before cooling immediately to 50° F., and (2) The High Temperature Short Time method where milk is held at a temperature of at least 161° F. for at least 15 seconds before cooling immediately to 50° F.

(*b*) *Sterilised Milk*—Where milk is held at 212° F. or up to 225° F. in autoclaves for at least half an hour. This milk is heated in the bottle and cannot be cooled quickly.

Both these methods destroy milk souring organisms, but they are not a cure for poor methods of production. It has been shown, especially under summer temperatures, that raw milk with a high bacterial content has a less satisfactory keeping quality after pasteurisation than that of milk properly produced. There is also the question of flavour, and milk of a poor hygienic quality has a poor flavour after heat treatment.

Cleansing of Milk Equipment—(*a*) Immediately after milking, all equipment coming into contact with the milk must be rinsed in cold water. This removes most of the milk solids.

(*b*) Utensils should be thoroughly scrubbed in warm detergent solution to remove traces of fat and other milk solids which are not removed by the cold water rinse.

(*c*) Utensils should be sterilised to destroy any bacteria not removed by cleansing. The best form of sterilisation is in a steam chest at 210° F. for 10 minutes or by complete immersion in boiling water for 2–3 minutes, but chemical sterilising agents, e.g., sodium hypochlorite, are satisfactory if properly used.

Detergents—Detergents are cleansing agents and must not be confused with sterilising agents such as sodium hypochlorite. Commonly used detergents are washing soda or soda ash (sodium carbonate), trisodium phosphate, the sodium silicates and sodium hydroxide. The latter cannot be used for hand washing of dairy equipment owing to its effect on the hands. There is no necessity for an expensive detergent in normal farm practice and for stainless steel or tinned utensils, washing soda or preferably soda ash are satisfactory. Where aluminium equipment is used, it can be easily corroded by soda ash and it is advisable to use a detergent with a high proportion of sodium metasilicate.

The detergents have the property of emulsifying the fat on the surface of the equipment and promote easy removal. They are not efficient unless properly applied by scrubbing.

Sodium Hypochlorite—This is a sterilising agent with very little cleansing action, the use of which has only been allowed officially in Great Britain since 1941. It is not efficient when used with poorly cleaned utensils, attacking milk residues in preference to bacteria.

Brands of sodium hypochlorite must be approved by the Ministry of Agriculture and contain a small quantity of sodium chlorate to act as an indicator which can be detected if the hypochlorite is added to milk. The approved hypochlorites are at present sold under the trade names of Chloros, Deosan, Delsanex, Dairozone and Hyposan. The best method of application is as follows :—

(*a*) Rinse equipment thoroughly in cold water.

(*b*) Scrub thoroughly in chlorine-wash solution containing
¼ lb. soda ash or other dairy detergent or
½ lb. washing soda and 4 oz. of the sodium hypochlorite solution as purchased per 10 gallons of water at 110°–120° F.

(*c*) Rinse in water to which sodium hypochlorite has been added at the rate of 1 oz. per ten gallons.

HYGIENIC MILK PRODUCTION

The essential points are :—

1. Healthy and clean cows.
2. Keen personnel.
3. Healthy milkers with clean hands and clothing.
4. Clean, sterile milking equipment.
5. A good water supply.
6. Clean cowsheds.
7. Good cooling and storage.
8. A good milking routine including discarding the foremilk.

MILK EQUALISER

On account of the variations in the milk from different cows during the course of the milking, there is often a difference in butter-fat content of the milk in churns making up any consignment. To obviate this, the equaliser which is fitted below the cooler is used to distribute the milk equally over several churns at once so that the butter-fat contents of all are the same.

This cannot be adapted for bottled milk, and here it is essential that milk from as many cows as possible should be bulked together before bottle filling commences.

Refrigeration

Milk should be cooled to below 60° F. before sale. This can be done with a surface cooler, but the efficiency of cooling depends on the water supply used. A good deep well provides water at 52°–53° F., which enables milk to be cooled to 54°–55° F. at all periods of the year. Where mains water is used, its temperature fluctuates and, during hot summer weather, it may be impossible to cool below 75° F. Mechanical coolers may be necessary under such circumstances and may be of the direct expansion, chilled water or immersion types.

With surface coolers, it is possible to cool to within 2° F. o the water temperature by passing water through the cooler a three times the rate of milk flow. This requires considerable care in adjusting the rate of flow.

MILK TESTING

Butter Fat Determination—The only accurate method o determination of butter-fat is by extracting the fat with a suitable solvent and weighing it. However, the Gerber metho —which depends on dissolving the proteins with sulphuri acid and separating the fat by centrifuging in a calibrate butyrometer—gives very reliable results when properly carrie out. Eleven ml. of milk is mixed with 10 ml. of sulphuri acid (s.g. 1·82—1·825) and 1 ml. of amyl alcohol (s.g. 0·810–0·812). All equipment should be checked for accuracy, spee of centrifuge should be 1,100 r.p.m., and spinning should b continued for at least four minutes.

Determination of Total Solids—The most accurate metho is by drying at 100° C. A routine method which gives sati factory results depends on determination of the butter-f content by the Gerber method, and either the density or speci gravity by an hydrometer. The total solids can be calculate from the following formulæ :—

$$T.S. = 0{\cdot}25\,S + 1{\cdot}2\,F + 0{\cdot}14$$

where T.S. = Total Solids,
S = (Specific gravity at 60° F. − 1·000) × 1,000
and F = Fat
(Droop Richmond Formula)

Or $T.S. = 0{\cdot}25\,D + 1{\cdot}2\,F + 0{\cdot}66$
where D = (Density at 20° C. − 1·000) × 1,000
(British Standards Institution formula—B.S.S. 734)

These routine methods have been shown to give reliab results for bulk milk and for samples from individual cows wi normal butter-fat contents of 2·0 to 6·0 per cent., but there ma in some instances, be quite wide variations from the figur obtained by drying.

Dye Reduction Tests—These have, to a large extent, replaced bacteriological methods depending on determination of numbers of bacteria or specific organisms such as the coliform group which produce both acids and gas from lactose. It is essential that samples should be aged before testing, as all milks will give a satisfactory result which gives no indication of the hygienic quality if the tests are carried out immediately after milking. They are carried out by adding 1 ml. of a dye such as methylene blue or resazurin to 10 ml. of milk and incubating at 37° C. The products of bacterial activity bleach the dyes and the test is complete for methylene blue when the dye is completely decolourised.

Milks produced under the Milk (Special Designations) Regulations, 1949, should not decolourise methylene blue in 5½ hours in winter (November to April), or 4½ hours in summer (May to October).

The resazurin test is used as a measure of marketability. The dye resazurin is reduced by bacterial activity from purple through pink to colourless. The test is carried out by adding 1 ml. of standard resazurin solution to 10 ml. of milk, and then incubating at 37° C. for ten minutes. Any consignments which completely decolourise the dye are rejected as having poor hygienic quality and, for certain purposes, milk which reduces resazurin to the violet or pink stage may be returned to the producer.

Freezing Point Test (Hortvet)—At certain periods of the year, milks may be genuine and yet fall below the presumptive legal standards for either fat or solids-not-fat. The freezing point of milk indicates whether milks are genuine or whether they have been adulterated with water. Milk freezes at a lower temperature than water and the addition of water brings its freezing point nearer to that of water, i.e., the difference between the freezing point of water and that of milk—the freezing point depression of milk—is reduced by the adulteration.

The freezing point is determined with special apparatus, and it has been shown that the average freezing point depression of milk is 0·545° C. and for individual samples rarely falls below 0·530° C. If a milk has a freezing point depression of 0·529° C. or less, it can be taken as evidence that the milk has been adulterated. The test is not a statutory one, but it is used generally to provide confirmation of the results of butter-fat and solids-not-fat determinations.

Titratable Acidity—The so-called acidity of fresh milk when titrated with alkali using phenolphthalein as an indicator is due to the protein, soluble phosphates and carbon dioxide. The figure obtained will therefore, to some extent, depend on the solids-not-fat content of the milk. The development of lactic acid during souring increases the value obtained.

The titratable acidity is usually determined by taking 10 ml. of milk or whey, adding 1 ml. of a solution containing 0·5 per cent. phenolphthalein in 50 per cent. alcohol and titrating with N/9 sodium hydroxide solution (containing 4·444 gr. per litre) until a faint pink colour is obtained. The result is reported as percentage of lactic acid, given by the number of millilitres of sodium hydroxide used divided by 10, as 1 ml. of N/9 alkali is equivalent to 0·01 gr. of lactic acid.

The initial acidity of milk is usually between 0·140 and 0·160 per cent. lactic acid. A lower figure is obtained with milk from cows infected with mastitis or at the end of the lactation, and a high figure for cows immediately after calving.

Specific Gravity and Density of Milk.

Normally, the specific gravity of milk is determined at 60° F. (15·5° C.) and the density at 20° C.

The normal range is :—

Specific gravity	(60° F.)	1·026 to 1·036
Density	(20° C.)	1·025 to 1·035

The specific gravity and density of milk are reduced by addition of water.

When cold milk is allowed to stand at air temperature, th specific gravity and density increase until, at about 12 to 2 hours after milking, they reach a maximum. This phenomeno is known as the Recknagel contraction and is probably due t solidification of the butter-fat globules, hydration of the protein and loss of carbon dioxide. The effect of this facto should always be guarded against in determinations of specifi gravity or density and, to obtain standard conditions, the mil should always be warmed to 40° C. and then cooled to th temperature at which the determination is carried out.

Skimmed milk has a higher specific gravity than the origin milk because of the removal of the less dense fat.

Methods of Calculating Extent of Adulteration of Milk.

If the butter-fat content of milk falls below 3·0 per cen or the solids-not-fat content below 8·50 per cent., it may presumed, until the contrary is proved (Food and Drugs Ac 1938), that the milk has had fat abstracted or that water h been added. The minimum per cent. of fat abstracted or wat added may be calculated as follows :—

Minimum per cent. of fat abstracted =

$$\frac{(3-\text{Fat per cent. in milk})\times 100}{3}$$

Minimum per cent. of added water =

$$\frac{(8{\cdot}5-\text{S.N.F. per cent. in milk})\times 100}{8{\cdot}5}$$

Where the freezing point (Hortvet) determination can be carried out, and an appeal-to-the-cow sample is available in the case of a suspect milk the added water present may be calculated by means of the formula

$$\frac{T-T1}{T}\ \text{x}\ (100-\text{t.s.})$$

where T = Freezing point depression of genuine (i.e., unwatered, appeal) sample.
T1 = Freezing point depression of suspect (adulterated) sample.
t.s. = Total solids.

Should appeal-to-the-cow samples be not available T may be taken as 0·530°C. except for samples of over 200 gallons when the value for T should be taken as 0·540°C. In such cases, it has been suggested, the following simple formula may be used :—

$$\frac{T-T1}{T}\ \text{x}\ 100$$

This calculation is applicable to nearly all samples since the freezing point of genuine milk varies within the narrow range −0·530°C. to −0·550°C. very few cases occurring of cows which produce milk that falls outside these limits.

Taints in Milk.

These may be due to a number of causes :—

(*a*) Absorbed odours,
(*b*) Chemical taints,
and (*c*) Bacterial taints.

Milk readily absorbs odours giving "cowy," paraffin, disnfectant or silage taints. It is therefore important that milk hould always be handled in clean, sweet-smelling premises.

Chemical taints may be due to advancing lactation or disease of the udder, illness of the cow as in acetonæmia, food consumed by the cow or changes in the fat brought about by the action of oxygen in the presence of light or traces of copper. Lactational changes or mastitis may give a salty flavour, anc acetonæmia a taint due to the presence of acetone.

Food taints are very common and may be due to :—

(*a*) Feeding excessive quantities of turnips or other root or rape kale, especially in a slightly decomposed condition.
(*b*) Feeding sugar beet products, and particularly molasse sugar beet pulp, which produces a fishy flavour.
(*c*) The presence of weeds such as garlic, mustard and eve clover.

Food taints can usually be eliminated by feeding foods suc as turnips and sugar beet products immediately after milking Weed taints can only be overcome by removing them from th pastures or, in the case of clover, by controlled grazing.

Bacterial taints are caused by the growth of organisms whic produce aroma and flavour-producing substances from th milk constituents. These flavours may be "malty," fruit or even turnipy, and they are always absent from the mil immediately after milking, but develop on standing. Th differentiates them from the absorbed and chemical taint with the exception of the "oily" or "cardboard" taints cause by the action of sunlight, or the presence of small quantiti of copper derived from badly tinned copper equipment.

Bacterial taints can be controlled by thorough cleanline and sterilisation of all equipment. Occasionally, infected wat supplies may be responsible and, in this case, a small quanti of sodium hypochlorite can be used in the water used for washi the cows.

"Ropy milk," due to bacteria which cause the milk to dra into long threads, is another trouble which, although not taint, may be controlled in the same way as a bacterial tai

MILK RECORDING

It is beneficial to weigh the milk night and morning at regul intervals—daily, weekly or monthly—to determine the mi producing capabilities of the animals in the herd. This essential for culling, breeding and feeding. Weighing is mo accurate than measuring, and weights in lb. can be convert easily to gallons by dividing by 10·32—the average speci gravity of milk.

Recording the weight of milk need not be carried out und any official scheme, but it is usually found to be an advanta especially where cows and bulls are sold off the farm and wh officially recorded animals command a better market. addition, the official schemes—in all countries—provide butter-fat testing service which enables breeding to be bas on quality in addition to quantity of milk. This is important, as the butter-fat content tends to decrease with increasing yields, and it is only by attention to both that the quality of the milk can be maintained.

In England and Wales, official milk recording is administered by the Milk Marketing Board through National Milk Records and its branch committees, the scheme being introduced in 1942 when it replaced the scheme administered by the Ministry of Agriculture. In Scotland, the scheme is administered by Scottish Milk Records and in England, Wales and Scotland, financial assistance is given by the Government.

A milk record should give at least the following particulars :—

1. Sire.
2. Dam.
3. Ear mark or number of cow and name of cow.
4. Breed.
5. Age and number of calves produced.
6. Date of birth of last calf.
7. Date next due to calve.
8. Number of days in milk.
9. Weight of milk produced during lactation.
10. Percentage of fat calculated on a lactation basis and number of samples examined.

CREAM

Cream may be obtained from milk either by hand skimming or by mechanical separation. For hand skimming, the milk is " set " in shallow pans to allow the cream to rise, and this is then skimmed off with a scoop 12 to 24 hours later. During setting it is advisable to keep the milk as cool as possible to prevent souring and development of taints. Hand skimming is inefficient leaving a high proportion of fat in the skimmed milk— 0·25 to 0·5 per cent., does not allow the proportion of fat in the cream to be controlled, and may also give a cream of poor keeping quality because of the growth of the milk bacteria during setting. This method of obtaining cream has been almost entirely superseded by the mechanical method of separation except in the manufacture of Devonshire and Cornish clotted cream. In this case, the milk is set in shallow pans at 60° F. for 12 hours. The temperature of the milk is then raised to 180°–190° F. and held at this temperature until the surface becomes wrinkled. The cream takes on a " broken " appearance on cooling. It is then skimmed by hand. Losses of butter-fat are less by this method, and the cream has a better keeping quality.

In mechanical separation, the milk passes in a continuous flow through plates revolving at 5,000 revolutions per minute or more. By this means, the rising of the fat globules is assisted by centrifugal force, as the heavier skimmed milk is thrown towards the outside of the plates and the lighter fat globules accumulate nearer the centre. The cream obtained can be drawn off from the centre of the plates and the skimmed milk from the outside. Mechanical separation is most efficient when the temperature of the milk is at least 95° F. Mechanical separation has the advantages that a high proportion of the butter-fat is removed, leaving not more than 0·1 per cent. of fat in the skimmed milk, and that a " fresh " cream is obtained. In addition, the percentage of fat in the cream can be regulated by adjustment of the cream screw.

The proportion of butter-fat in the cream should be varied according to the purpose for which it is required. A thin cream containing about 20 per cent. of butter-fat is suitable for coffee and fruit, one containing 30 to 40 per cent. fat for buttermaking, and over 40 per cent. for whipping. If the percentage of fat in the milk is known, the approximate percentage of fat in cream is given by the formula :—

$$\frac{(\text{percentage fat in milk} - 0{\cdot}1) \times \text{volume of milk used}}{\text{volume of cream obtained}}$$

The percentage of fat in cream is most accurately determined by extraction of the fat with a suitable solvent, and weighing the fat obtained, but a comparable figure can be obtained by the Gerber method, using 5 gm. of cream in a special butyrometer.

The specific gravity of cream varies with the fat content from 1·027 to 0·95, but may be taken as an average of 0·985 equal to 9·85 lb. per gallon.

Starters.

A starter is a culture of lactic acid bacteria used to inoculate milk or cream to increase the rate of " ripening " in cheese and buttermaking. When milk or cream are ripened naturally, i.e., by the organisms already present, the resulting product may be poor because of fermentations which produce taints and other abnormalities. A vigorous and pure starter prevents these and results in a better and more uniform product.

The role of starters in cheesemaking is to produce the lactic acid required in the cheesemaking process and to overcome the growth of other organisms which may lead to "off flavours." In butter-making, the starter is used to prevent the growth of organisms which may cause rancidity, to improve the churning properties of the cream, and the flavour and aroma of the butter.

Starters consist of lactic acid producing streptococci, e.g., *streptococcus lactis* and *S. cremoris*, and occasionally lactic acid producing rod-shaped bacteria—*lactobacilli*. The ability of butter starters to produce the substance diacetyl—responsible for flavour and aroma—varies considerably with the strain of lactic acid bacterium. Some cultures have aroma producing bacteria present, e.g., *S. citrovorous*, although these produce very little lactic acid.

Propagation—Starter cultures may be obtained in liquid form from the dairy colleges or commercial firms. The life of a liquid culture is short, and the starter should be propagated as soon as received. "Powder" cultures can also be obtained which have the advantage of a fairly long life, but require repeated sub-culture before they are ready for use in either butter or cheesemaking.

Propagation should be carried out daily as follows :—

(*a*) Select a clean bulk of milk and pasteurise by heating to 180° to 190° F. for at least 60 minutes.
(*b*) Cool to 72° F.
(*c*) Inoculate with 1 per cent. (approximately 1½ oz. to each gallon of milk) of the starter culture.
(*d*) Store in a warm, clean room at a temperature of approximately 70° F.
(*e*) Repeat this procedure each day.

It is necessary to take every care in propagation of a starter as contamination with bacteria, yeasts, moulds or bacteriophage may seriously affect the butter or cheese made with it. It is therefore essential to sterilise all equipment used in the propagation of the starter and take every precaution to prevent contamination from the air. A starter is best propagated in a seamless container with a close fitting lid.

When propagation is properly carried out, the titratable acidity 20—24 hours after inoculation should be 0·8 to 0·9 per cent. lactic acid. The curd should be smooth with no evidence of gas, and the starter should have a clean acid smell.

Rennet.

Rennet solution as used in cheesemaking is a brine extract of the rennin which is present in the fourth stomach of the very young calf. The "vells" are collected from slaughter houses in all parts of the world, dried and despatched to the rennet factories where they may be stored until required. Rennet prepared from them contains the enzyme pepsin in addition to rennin. It is also possible to obtain rennet in tablet or powder form.

Rennet slowly loses strength in storage, and the loss is accelerated by the action of sunlight or high temperatures. Rennet tablets or powder retain their activity longer than liquid preparations.

The rennet acts on the calcium caseinate of the milk, with the precipitation of calcium paracaseinate.

Annatto.

The colouring matter present in annatto is obtained from the seeds of the shrub Bixa orellana which contains a reddish yellow pigment—bixin. Cheese annatto is an alkaline aqueous extract of the seeds, while butter annatto is a solution of bixin in oil.

CHEESE

Cheesemaking probably originated as a method of preserving food in periods of plenty for periods of scarcity. Each district or country used its own methods for preserving the curd which was separated from the milk and, from these, developed the various varieties of cheese with their own characteristic flavours. The basis of all cheesemaking processes is the precipitation of the curd—which consists mainly of casein, fat and some of the mineral salts—by the action of acid or rennet. This leaves the whey which contains nearly all the lactose of the original milk and some of the fat, proteins and ash.

The type of cheese obtained is dependent on the method of manufacture. The chief factor involved is the moisture content which is controlled by the acidity developed at various stages of manufacture, the quantity of rennet used, the temperature attained at various stages, and the extent to which the curd is "pressed" to expel moisture.

The various types of cheese manufactured in Great Britain may be classified as follows :—

(*a*) *Hard pressed cheese*—Caerphilly, Cheddar, Cheshire, Derby, Lancashire, Leicester.

The method of manufacture is such as to provide conditions which favour ripening by bacteria and rennet.

(*b*) *Blue veined cheese*—Stilton and Wensleydale.

These are mainly ripened by the blue mould—*Penicillium roqueforte*—and the methods used are such as to give a cheese which favours the growth of this organism.

(*c*) *Soft cheeses*—There are no typical British soft cheeses but French cheeses such as Camembert, Coulommier and Pont L'Eveque can be made under English conditions.

1. The milk used should be of good chemical and hygienic quality. The former is necessary to obtain a good yield of cheese from each gallon of milk, while milk of poor bacteriological quality may result in " off flavoured " cheese as well as causing other troubles.

2. **Ripening the Milk**—Acidity must be developed in the manufacture of hard-pressed cheese before rennetting, and does much to determine the course of acidity development during the succeeding processes. Starter is added to promote development of acidity, the milk being maintained at 85° to 90° F., the temperature at which starter organisms grow best. The quantity will vary with different cultures, but generally it may be said that the quantity which produces sufficient acidity for rennetting in 1–1½ hours is best.

3. **Rennetting**—Rennet is added to coagulate the curd, and the quantity, temperature and acidity of milk required vary with the variety of cheese. The rennet should be diluted with 3 or 4 times its volume of water before stirring into the milk.

4. **Cutting the Curd**—Cutting the curd into small particles assists removal of whey, the size of particle being smallest when a cheese of lowest moisture content is being made.

5. **Scalding**—Draining of the curd is assisted by raising the temperature of the whey above 90° F.—scalding. During scalding, the temperature of the whey is raised by about 1° F. every 3–4 minutes with continual stirring. If it is carried out more quickly, the surfaces of the curd particles are closed and too much whey is retained.

6. **Pitching**—The curd is allowed to fall to the bottom of the cheese vat. It may be allowed to remain in the whey for varying times or until a definite acidity has been attained by the whey.

7. **Drawing off Whey**—After pitching the curd lies as a mat on the bottom of the vat. The whey is run off and draining of the curd assisted by cutting and piling.

8. **Milling**—After the curd has attained the correct acidity and dryness, it is milled or ground and salted.

TYPICAL PROCESSES FOR HARD-PRESSED CHEESE

	Cheddar	Cheshire
Temperature of milk ...	86° F.	86° F.
Quantity of starter ...	½–1½ per cent.	½–1 per cent.
Acidity at rennetting ...	0·18–0·22 per cent.	0·22–0·23 per cent.
Temperature at rennetting	**85–86° F.**	**86° F.**

	Cheddar	Cheshire
Quantity of rennet ...	1 oz. to 30 gall. of milk	1 oz. to 16-20 gall. of milk
Size of curd	small pea	small bean
Acidity after cutting ...	0·14–0·15 per cent.	0·14 per cent.
Temperature of scald ...	96–105° F.	89–93° F.
Acidity at pitching ...	0·175–0·19 per cent.	0·16 per cent.
Acidity when whey drawn off	0·24–0·28 per cent.	0·19–0·20 per cent.
Acidity at milling ...	0·65–0·95 per cent.	0·75–0·85 per cent.
Amount of salt ...	1 oz. to 3 lb. curd	1 oz. to 3 lb. curd

Pressing—After milling and salting, the curd is filled into moulds which, with Cheddar cheese, are immediately put into a press and bandaged after two or three days. For Cheshire cheese, the curd is held in the moulds in a room at 65° to 70° F. until the following day, when it is pressed for one or two days before bandaging.

Storage—After bandaging, Cheddar and Cheshire cheese should be stored at 55°–60° F. to ripen, and each cheese turned daily for at least one month. During storage, various chemical changes take place under the action of the rennet, pepsin and bacteria. The casein is broken down into soluble substances which are responsible for the flavour of the cheese.

Blue Veined Cheese.

In the manufacture of this cheese, the milk is rennetted sweet, there is no scalding, and the whey is slowly expressed in cloth bags. The curd, after drainage, is broken up into coarse lumps which are filled into moulds, salt being added at the rate of 1 oz. to 2½ lb. of curd. The curd is not pressed and the necessary water and air conditions inside the cheese allow of growth of the penicillium mould which usually is present in the milk or which gains entry to the curd during manufacture

Defects of Cheese.

Slowness of Starters—(*a*) *Inhibitory Milk*—Certain organisms which develop on the surfaces of badly cleaned and sterilised utensils grow in milk and produce substances which slow the growth of the starter bacteria. All milk for cheesemaking must be produced in clean, sterilised utensils.

(*b*) *Bacteriophage* (*phage*)—It has been demonstrated that an ultra-microscopic infection of starters—phage—causes destruction of the starter organisms. This infection grows only in the presence of the particular starter bacteria and destroys the cells. The infection in the whey is not serious, but when it gains entry to the starter itself, it can inhibit the development of acidity completely. Where there is phage infection, the milk usually ripens normally, but acidity development ceases during stirring and scalding and may not recommence for 12 hours or more.

It can be controlled by scrupulous attention to the propagation of the starter and especially prevention of all contamination with whey. When the trouble is experienced, it is advisable to obtain an unrelated starter from an entirely new source and to replace the starter at frequent intervals.

Taints in Cheese—These may be due to the use of a contaminated milk or poor methods of manufacture which result in a wet curd. They may also be caused by a weak starter which allows the milk bacteria to gain the ascendency.

A starter infected with yeasts may give a " yeasty " cheese with evidence of slight gas production.

Floating Curd—This is caused by the coliform organisms which produce lactic acid and the gases carbon dioxide and hydrogen from milk. These gases become trapped in the curd particles which then rise to the top of the vat and often split through the pressure of gas inside the particles. It is caused by an infected starter or, more frequently, by the use of milk of very poor bacteriological quality.

Colour Faults—" Red spot " in cheddar cheese is caused by a red colour producing organism in symbiosis with other bacteria.

" Mottling " of cheese coloured with annatto may be caused by incorrect acidities.

TABLE 143
AVERAGE YIELD OF CHEESE FROM MILK OF DIFFERENT BUTTER-FAT CONTENTS

Per cent fat in milk	lb. of cheese per gallon of milk	lb. of cheese per lb. of fat
3·00	0·83	2·77
3·25	0·89	2·75
3·50	0·95	2·70
3·75	1·01	2·67
4·00	1·06	2·65
4·25	1·12	2·63
4·50	1·17	2·59
5·00	1·29	2·58

TABLE 144
COMPOSITION OF WHEY

	Per cent.
Water	93·04
Total solids	6·96
Fat	0·36
Proteins	0·84
Lactose, salts, etc.	5·76

BUTTER

Under the Food and Drugs Act, 1938, butter must not contain more than 16 per cent. of moisture. There is no legal standard for salt content, but the Minister of Food has laid down that it should not exceed 2·0 per cent. when manufactured in premises licensed by him.

Butter varies widely in composition. Creamery butters usually contain about 15·5 per cent. of moisture and 1·5–2·0 per cent. of salt, while farm butters are much more variable, containing from 10–20 per cent. of moisture and a variable proportion of salt. The curd content of creamery butter rarely exceeds 0·5 per cent. but again, farmhouse butter may contain variable amounts, being high in unwashed butters or where the churning process has been carried too far.

The flavour of butter from unripened cream is due to the flavour of the butter-fat enhanced by the salt. The "nutty" flavour of butter manufactured from ripened cream is due to the flavour producing substance diacetyl, produced by the starter organisms.

The keeping quality of butter is determined to a large extent by the methods of manufacture. Butter from pasteurised unripened cream keeps for long periods in cold store, while butter from ripened cream, especially if the acidity of the cream at churning exceeds 0·22 per cent. lactic acid, may rapidly develop a "fishy" taint under the same conditions. Infection of the butter during manufacture or from the original cream leads to poor keeping quality, as bacteria, yeasts and moulds cause rapid development of rancidity. The presence of excessive amounts of casein or buttermilk caused by poor methods of churning or washing also reduces the keeping quality, and such butters often become "cheesey."

Manufacture.

1. The milk used for butter manufacture should be produced under good hygienic conditions.

2. The cream should be separated from the milk by means of mechanical separator, as this reduces the losses of butter-fa as compared with setting and hand skimming. The crea obtained is also fresh and sweet, and the percentage of fat ca be regulated to 30–35 per cent. which is most suitable f churning.

3. **Cream Ripening**—To obtain a good flavoured butter f quick consumption, the cream should be ripened either naturall or by the addition of starter. Natural ripening is carried o by mixing together the cream of two or three days and holdin at 56°–60° F. for churning on 3rd or 4th day. Natural ripenin

is not recommended as it may result in butter of poor flavour and keeping quality caused by organisms derived from the milk.

When a starter is used, the cream should be heated to 150°–160° F. for 20 to 30 minutes and cooled immediately to 60°–70° F. A small quantity of starter—1 to 2 per cent.—is then added to the cream which is then allowed to ripen for about 24 hours at 60° F. If small quantities of cream are separated daily for churning once or twice a week, the first batch of cream should be ripened by using a small quantity of starter—often less than 1 per cent.—and each succeeding day's cream is pasteurised and cooled before stirring into this.

4. **Churning**—Cream may be churned at 57° F., but it is advisable to adjust the temperature of the cream at least three hours before churning, as shown in the following table :—

TABLE 145

Temperature in Dairy °F.	Temperature of Cream °F.
62	53
60	54
58	55
56	56
54	57
52	58
50	59
48	60

The churn should never be more than half filled, and the butter should come in 20–40 minutes. Churning should cease as soon as the butter "breaks." Cold breaking water should then be added and churning continued until the butter grains are of about the size of a mustard seed or slightly larger, but never into lumps.

5. **Washing**—After the butter-milk is drawn off, the grain is washed twice to remove the casein.

6. **Salting**—Mild salting can be carried out by covering the grain in the churn with brine containing 1–2 lb. of salt per gallon of water and allowing the grains to soak for about 20 minutes.

For salt butter, dry salting is usually adopted—¼ to ½ oz. of fine, dry, clean salt per lb. of butter being added to the grains immediately after removal from the churn.

7. **Working**—The object of "working" is to remove excess moisture by means of the roller on the butter worker. This operation should be carefully carried out to ensure a good texture.

8. Faults of Butter—*Sleepy Cream*—This refers to cream which adheres to the surfaces of the churn with the result that churning is delayed. It may be caused by milk from cows nearing the end of their lactation, the temperature of the cream being too low at churning, overfilling the churn, or the use of cream which is too thick.

Frothy Cream—May be caused by improper ripening, resulting in the development of yeasts and coliform organisms.

Poor Flavour—Caused by ripening conditions which favour the growth of bacteria other than lactic acid producing organisms. Foods which cause taints in milk may also result in taints in butter.

Colour Defects—Contamination with yeasts and moulds can cause dark green and even pink discolouration of the butter. Streakiness may be due to poor washing of the grain, to over-churning or to lack of care while dry salting.

Proportion of Butter Yielded—Approximately 2½ gallons of average milk containing 3·65 per cent. of fat are required to produce one pound of butter.

USEFUL DATA

Temperatures—

Milk from cow	98° F.
Milk uncooled in churn	90–95° F.
Milk separated at ...	90–100° F.
Sterilising	212° F.
Pasteurising milk ...	145–150° F. for 30 minutes. 161° F. for 15 seconds.
Pasteurising cream ...	155–160° F. for 30 minutes.
Pasteurising milk for starter	180–190° F.

Average freezing point of milk (Hortvet) −0·545° C. (31° F.).

Utensils—All utensils used for milk should be seamless and of a type which can be easily cleaned and sterilised. All metal work should be tinned or made of a metal such as stainless steel or aluminium. Galvanised utensils must never be used.

Milking Pails—Most convenient size about four gallons.

Milking Machines—There is a wide variety of bucket type plants. In addition, there is the bail type suitable for milking in the field, and the auto recorder or parlour type which can be used for cows housed in covered yards.

Coolers—A surface cooler of adequate capacity should always be selected so that cooling can take place rapidly. A safe rule is to select a cooler of at least twice the size required.

Mechanical cooling is becoming more popular, and coolers may be of the direct expansion type (where direct expansion of the refrigerant gives the necessary cooling) or utilise chilled water or brine. The latter use a smaller compressor, as the cold can be stored. In some instances, immersion coolers are recommended, and these have the advantage of reducing the equipment required, as the milk is cooled in the churn.

Milk Cans or Churns—The cans in common use are of 10 and 12 gallon capacity, and must be fitted with a close-fitting, mushroom-type lid. The standard can recommended by the British Standards Institution is of 10 gallon capacity and weighs about 31 lb.

TABLE 146

STANDARDS FOR MILK PRODUCED UNDER LICENCE.

The general conditions laid down for production of milk are given in the Milk and Dairies Regulations, 1949. In addition, the Milk (Special Designations) (Raw Milk) Regulations, 1949, and the Milk (Special Designations) (Pasteurised and Sterilised Milk) Regulations, 1949, lay down hygienic standards for milk produced under licence.

RAW MILK—LICENCES ISSUED BY THE MINISTER OF AGRICULTURE AND FISHERIES.

Designation of Milk	Herds	Hygienic Standard	Other Conditions
Tuberculin Tested...	All milking cows to satisfy tuberculin test and be clinically examined at regular intervals.	Submitted to a methylene blue test monthly. Shall not decolourise methylene blue in $4\frac{1}{2}$ hours or less in summer (May to October inclusive) or $5\frac{1}{2}$ hours in winter (November to April inclusive) when submitted to the prescribed test. Samples to be stored at atmospheric temperature before carrying out the test for the following periods : Evening milk—until 10 a.m. on the day following production. Morning Milk—until 6 p.m. on the day of production. Mixed Milk—treated as milk from most recent milking.	Must be consigned to the retailer in properly sealed unventilated churns, or must be bottled on the farm. Bottling premises must be licensed. After 30th September, 1954, applications for new or renewal of existing Tuberculin Tested licences will only be granted to attested herds in which all animals have passed the tuberculin test. The designation " Accredited " will be withdrawn after 1st October, 1954.
Accredited	Milking cows to be clinically examined at regular intervals.		

TABLE 147

PASTEURISED AND STERILISED MILK—LICENCES ISSUED BY THE MINISTER OF FOOD

	Heat Treatment	Standards	Other Conditions
Pasteurised and Tuberculin Tested (Pasteurised)	Milk heated to not less than 145° F. or more than 150° F. for at least 30 minutes OR to not less than 161° F. for at least 15 seconds or any other time/temperature combination approved by the Minister of Food.	Must satisfy the prescribed phosphatase test. Must not decolourise methylene blue in ½ hour or less when the test is carried out on milk which has been stored at atmospheric temperature not exceeding 65° F. until 9 a.m. on the day following delivery to consumer.	Premises must be approved and licensed.
Sterilised ...	Homogenised milk heated in the bottle to not less than 212° F.	Must satisfy the prescribed turbidity test.	Premises must be approved and licensed.

BEEKEEPING

Information Relating to the Craft as Practised in Great Britain

The Honey Bee, besides producing honey and wax, plays an important part in the pollinating of certain crops and this is especially true in areas wherein intensive cultivation has reduced the number of wild bees.

Species, Races and Strains—The Honey Bee, *Apis Mellifera L.*, belongs to the

Class	...	Insecta.
Order	...	Hymenoptera.
Family	...	Apidae.

Various races of the Honey Bee are known but in Great Britain the majority of the bees now kept are hybrids with predominantly Italian characteristics.

To commence beekeeping the selection of the right strain is vital and the prime selective factor must be the *honey-producing capacity.*

This is related to—

(*a*) Prolificacy of the Queen—Different areas require different degrees of prolificacy, but in areas where long heavy flows are common, lack of prolificacy is often a limiting factor.

(*b*) Swarming Propensity—Many factors cause a colony to swarm but selection must be made from strains which show the least tendency to swarm.

(*c*) General Stamina—This is related to the length of life of individual worker bees in the active season and resistance to disease.

Life history of the three Castes in days.

	Queens	*Workers*	*Drones*
Egg hatches	3rd	3rd	3rd
Cell is sealed over	8th	8th—9th	10th
Adult emerges	15th—16th	21st	24th

The **Queen** and **Workers** are females and develop from fertilised eggs.

The **Drones** are males and develop from unfertilised eggs.

Length of Life—Queens have an average effective life of three years. Drones have an average effective life of one season. Workers have an average effective life of six weeks in the summer.

Virgin Queens mate from the 6th–11th day after emergence and lay on the 2nd–3rd day after mating.

Queens lay from 1,000–5,000 eggs per day, 2,000 a good average.

Beehives—The modern movable comb hives are based on the observed fact that a space between $\frac{3}{16}$th and $\frac{3}{8}$th of an inch, in a hive, remains free from wax and propolis.

Types of Hives—(*a*) Single Walled, e.g., National and M.D. always used by commercial producers of honey as they are cheaper to buy, need less labour to handle and are more easily transported.

(*b*) Double Walled, e.g., W.B.C. Used largely by amateurs, and whilst ornate in appearance they have little else to commend their use.

Hives may be compared on the basis of comb area in the Brood Chamber.

TABLE 148

Beehives in common use compared on the basis of total comb area in Broodchamber—

	Total area of comb surface available in Broodchamber (sq. in.)	*Number and types of Frames.*	*Single or double walled.*
W.B.C. ...	2,126	10 British Standard	Double
National ...	2,340	11 British Standard	Single
Smith	2,340	11 British Standard	Single
Langstroth ...	2,740	10 Langstroth	Single
National or Major British Jumbo	3,110	11 British Commercial	Single
Glen	3,180	15 British Standard	Double
Modified Dadant (Standard)	3,760	11 Modified Dadant	Single
Buckfast M.D.	4,100	12 Modified Dadant	Single

The optimum area of comb required in the broodchambe varies with the degree of prolificacy of the queen.

Honey—Nectar is collected as a watery solution of sugar and this is "inverted" by the bees to a mixture of levulos and dextrose. The mixture is concentrated by the evaporatio of moisture and stored in the cells of the comb.

TABLE 149

Typical Composition of Honey—

	Per cent.
Water	19·0
Levulose (Fruit Sugar)	39·9
Dextrose (Grape Sugar)	34·40
Sucrose (Cane Sugar)	1·90
Dextrine	1·60
Ash, i.e., Mineral Salts	·20
Undetermined Matter	3·0

Density—Average density is 1·416 at 60° F.

Food Value—One pound of honey has an average calorific value of 1,540 calories. The dextrose can be directly absorbed into the human blood stream without digestion and the levulose only requires a slight alteration. The vitamin content is very variable in amount and dependent on the amount of pollen present, which is generally small.

Mead—This is prepared by the fermentation of a solution of honey in water, approximately 4 lb. of honey to one gallon of water. A specially selected yeast should be used and by varying the type of yeast and amount of honey, different types of mead may be produced.

Wax—Beeswax melts at 147°–150° F. and is a valuable by-product from beekeeping. It is used in the manufacture of a large number of products, e.g., polishes and cosmetics.

Honey Plants—The most important plants are :—

(*a*) White Clover. This is an outstanding yielder under a variety of conditions.

(*b*) Red Clover. Only gives high yields under specialised conditions.

(*c*) Lime. Main source of nectar in urban areas.

(*d*) Heather. This is limited to special areas and is the most valuable late crop extending from early August to late September

Other Plants of Importance—Fruit Blossom, Charlock, Sainfoin, Mustard, Field Bean, Sycamore, Blackberry, Willow Herb, and Dandelion.

Yields—The average yield of surplus honey is 25–30 lb. per hive though some individual beekeepers average over 100 lb. per hive each year.

The Commencement of Beekeeping—The prospective beekeeper who wishes to remain an amateur will find the local Beekeeping Association willing to help and advise.

The essential equipment required to begin is as follows :—

One hive, complete with brood box, two supers, floor, roof, crownboard and frames fitted with wired foundation. One hive as above but with no supers.

Also required are veil, smoker, queen excluder, rapid feeder, hive tool and small extractor.

The bees are best purchased in early June as a strong nucleus headed by a young queen and should be obtained where possible from a commercial honey producer. Swarms should not be bought as they may be diseased.

In order to become a full or part-time commercial honey producer, a preliminary training on a honey farm should be obtained and the venture should not be undertaken unless sufficient capital is available. At the time of writing it is estimated that a unit of 100 hives requires a capital of £1,400 and extra capital would be necessary to build these stocks into a worthwhile commercial holding of upwards of 300 stocks before a satisfactory income could be expected.

The Honey Producers Association caters for commercial beekeepers who have 40 or more stocks.

Management—Owing to the large number of factors involved in beekeeping, many different systems have been evolved. The basic principles are :—

(i) The limiting factor to a commercial producer of honey is the capacity of the flora in his area to secrete nectar copiously over long periods.

The availability of nectar is dependent both on the flora and on the type of soil in which it grows.

(ii) In choosing a particular system, the economic advantages over other systems in the conservation of labour and materials must be the prime consideration.

(iii) All systems of management aim to have the hives up to peak strength at the onset of the main honey flow and, unfortunately, it is at this time that the colony is most prone to swarm. Hence the success of the method of swarm control is a critical test of the usefulness of any particular system.

Full details of the various recognised systems of management will be found in the standard text books on beekeeping. The following notes refer to specific points of management common to many such systems.

Swarming—Major causes of swarming are :—(i) Insufficient space for brood rearing ; (ii) Poor ventilation ; (iii) Age and strain of queen. (Young queens are less inclined to swarm.)

Prevention of swarming :—

1. Anticipate the rapid expansion of the brood nest and give more room *in advance*. This is the main principle in a number of swarm control methods, e.g., the "Demaree method," in which the queen is confined to a new brood chamber containing empty combs and separated from the brood by a queen excluder.

2. Requeen annually from a stock which tends to supersede rather than swarm.
3. Improve ventilation.

The Feeding of Bees with Sugar—The Autumn feeding of bees with sugar is standard practice largely due to the disparity in price between honey and sugar and it also ensures a supply of food around the cluster in winter.

A rapid feeder holding at least 10 lb. of syrup should be used, e.g., a 14 lb. honey can with a few holes in the lid and placed in an inverted position over the feedhole.

For Autumn feeding dissolve 2 lb. of sugar in one pint of water. For Spring feeding dissolve 1 lb. of sugar in one pint of water.

A minimum of 35 lb. of sealed stores is essential for the successful wintering of a colony.

Provision of Drinking Water—The provision of a source of clean water near the hives is an excellent practice.

Uniting Stocks of Bees—The " Newspaper " method is most commonly used. The two stocks to be united are placed with the weaker one on top of the other and two thicknesses of newspaper are placed between. Small holes should be pierced in the paper with a penknife and the operation is best undertaken as late in the day as possible.

Finding the Queen—When normal methods have failed the following procedure may be adopted.

Place a frame of emerging brood into a hive containing empty frames, and after shaking all the bees into this, move it to a new site. The older flying bees will return to the old site and the queen is easily found on the comb of brood which remains.

Tests for Queenlessness—Place a frame of three-day-old eggs into the colony, leave for three days and examine for the presence of queen cell cups. If none are present it proves that no queen is present.

Queen Introduction—1. It is always safer to introduce the new queen to a specially prepared nucleus hive, having emerging broods but no eggs present, and then unite this to the main colony.

2. If direct introduction is required the queen may be put into a travelling queen cage which has its exit plugged with candy. This is introduced into the centre of the brood nest and the queen is liberated when the bees eat through the candy.

The use of the Honey Bee for Pollinating Crops—In the last decade much greater use of the Honey Bee has been made by seed growers for pollinating purposes especially with the following crops.

Fruit—Many varieties of apples, pears, plums, and all sweet cherries cannot set fruit with their own pollen, i.e., they are self-incompatible. These varieties require pollen from a different variety of the same species and orchards are planned so as to interspace "pollinators" with main varieties.

As wind pollination is negligible, insect pollination is essential and this is not always effective when left to the wild insects. The Honey Bee can be used to ensure the necessary cross pollination.

Clovers Grown for Seed—Red and white clovers are also dependant on insect pollination and the importation of Honey Bees on to the seed crop is very likely to result in increased yields.

Brassicas Grown for Seed—All brassica crops grown for seed benefit from the pollinating activities of the Honey Bee, though care must be taken to see that they are properly isolated from other brassicas with which intercrossing is possible.

Soft Fruits, e.g., raspberries and blackberries, are also dependent on insect pollination, though some varieties o cucumbers are important exceptions.

General Notes—The colonies used for pollination purpose must be strong and should be sited in a sunny position on o as near to the crop as possible. The best results are ofte obtained by waiting until just after the onset of the mai flowering period before importing the bees, as under these con ditions they show the least tendency to wander from the crop.

One strong colony per acre is generally considered sufficien but experiments show that the most effective cross-pollinatio occurs when there is competition in the foraging area.

The payment required by beekeepers for importing hive varies from £1–£3 per colony and the risks undertaken by th beekeepers if toxic chemicals are used on the crop, e.g., dustin brassica seed crops to control the pollen beetle, have to b taken into account.

BEE DISEASES

(*a*) **Adult Bee Diseases**—

	Symptoms	*Causative Organism*	*Control*
Acarine	Weak, crawling workers often with swollen abdomens and unhooked wings	*Acarapis woodi*, a parasitic mite present in the anterior thoracic breathing tubes	Use of sulph fumes or Meth salicylate

	Symptoms	*Causative Organism*	*Control*
Nosema	Dwindling colonies some showing dysentery. Greyish white appearance of intestines	*Nosema apis*, a protozoan parasite	Only preventative control is possible, e.g., isolation of infected colonies.
(*b*) **Brood Diseases**—			
American Foul Brood	Kills and decomposes larvae after cells have sealed over. Sunken and perforated capping, distinctive odour, decaying larvae of "ropy" consistency	*Bacillus larvae*, a spore forming bacterium	Colonies must be destroyed under Foul Brood Order, 1942. Infested combs and bees must be burnt and hives disinfected.
European Foul Brood	Death of unsealed larval stages—they are often turned around in their cells before decay is pronounced	Appears to be related to the *Bacillus pluton*, a spore forming bacterium	As for A.F.B.

The Treatment for Acarine Disease—1. Sulphur fumes are obtained by burning cardboard impregnated with sulphur in a smoker.

A few puffs are given at the entrance each evening for three successive days, and this is repeated after a five day interval.

2. Methyl salicylate, or Oil of Wintergreen, is best used in the warmer months and is administered by placing a small tube containing the chemical absorbed in cotton wool on the floorboard of the hive.

N.B.—Only young bees up to five days old can be infected with the mite.

Hive Disinfection—The blow-lamp should be used for this purpose and where this is not possible the following solution :—

Washing soda 1 lb.
Bleaching powder ½-lb.
Water (hot) 1 gallon

should be scrubbed in and throughly washed out.

The Diagnosis of Bee Diseases—Samples of bees and brood in England and Wales can be examined for disease free of charge.

Samples of not less than 30 bees or one brood comb should be securely packed and sent to the Chief Bee Advisory Officer, National Agricultural Advisory Service, Rothamsted Lodge, Hatching Green, Harpenden, Herts.

General Information

British Standards Institution Definitions re Sale of Bees

(*a*) **Stock**—The term "stock" shall be used to denote a colony of bees offered for sale together with the hive.

(*b*) **Colony**—The term "colony" denotes a colony of bees occupying not less than six 14 in. by 8½ in. combs. In the case of 16 in. by 10 in. or 14 in. by 12 in. combs, not less than four combs are required.

(*c*) **Nucleus**—The term "Nucleus" denotes a quantity of bees occupying not more than five 14 in. by 8½ in. combs or three of the large combs referred to in (*b*) above.

(In (*b*) and (*c*) the number of combs shall be stated in each case.)

Weight of Bees—1 lb. of bees contains approximately 3,000–4,000 workers.

Number of Bees in Colony—A strong colony in two National brood boxes has been estimated to contain 80,000 workers in June and 10,000 in January.

Number of Bee Visits per pound of Honey—It can be calculated that to store in the hive 1 lb. of honey, 20,000 individual journeys may be required.

FARM MACHINERY

Ploughs

The trapezoidal furrow slice is objectionable in that it leaves some soil unmoved at the bottom of the furrow, is not firm, and, as it is narrower, takes a longer time to get over an acre. There is less open space below, however, and it cultivates down well.

The rectangular is better in most respects, and is the most common form, but does not cultivate down so easily as the preceding. Ploughs are usually made to allow the coulter to be set to cut perpendicularly.

The parallelogrammatic has some good points. It is crested, it is firm, all the soil is moved from bottom and it is wide in proportion to depth.

The wide broken form is the best, and is that made by the short, wide-set digger plough. It is suitable to and desirable on the lighter and more friable soils, but heavy clays can be quite satisfactorily pulverised by this means, though grassland does not work very well in some cases.

DISC COULTER—The best form of coulter. Cuts cleaner and easier than the knife form. Adjustable to all ploughs. Set at ½-in. wider than plough bottom ; well back and high for hard land and forward and low for stony land.

SKIM COULTER—Should be fitted on all ploughs to ensure clean work and that the surface growths are properly buried, so as to keep land free of weeds. A skim can be combined with a disc coulter, and the combination makes the best work of all and immensely helps towards clean farming. Cuts wide *flat* triangular slice.

POINTS OF GOOD PLOUGHING—

Straight, with even finished ends.
Depth to suit soil and crop.
Clean-cut land side and even bottom.
Laid regular and compact at 45°.
Grass, stubble, and rubbish turned in and covered.
Upper edges level to give even seed bed.
Small, even finishing furrows.

DISTANCE TRAVELLED PER ACRE—

99 ÷ width of furrow = miles per acre.

At a width of 8 in.	12·3 miles
,, ,, 9 in.	11 ,,
,, ,, 10 in.	9·9 ,,
,, ,, 12 in.	8·2 ,,

Average Time to Turn—Three-quarters of a minute for horse plough, half a minute for tractor plough.

Percentage of total ploughing time taken by tractor outfit turning at headlands varies from 12–16, by horses from 15–26.

Limit of Draught—6 cwt. per furrow. Ordinary ploughing varies from 3 to 5 cwt., or from 160 to 280 lb. per horse, or from 30 to 100 lb. for every inch of depth with slice 9 to 10 in. wide, depending on nature of soil, etc. This is equivalent to an average of about 6 lb. for every square inch of cross-section of furrow-slice. Speed in ploughing makes little difference in draught : the difference between 2½ and 4 miles per hour is only 7 per cent.

Varieties of Ploughs

Ploughs used in Britain are mostly of what is called the general purpose type. The mouldboard is short and is mostly concave to the ploughing. The furrow slices are very slightly broken, but they preserve their individual shape. A plough with a shorter mouldboard, more concave than that of the general purpose type, gives a furrow which is fairly broken It is usually called the semi-digger, and its use is spreading very rapidly. A true digger body produces furrow slices which have nearly lost their individual character.

It may be that the use of digger bodies, and even of semi digger bodies, ought to be reserved for spring work when planting is done soon after ploughing whilst general purpose ploughs or even lea ploughs ought to be used in the autumn whenever the land can lie undisturbed in furrow. But the fac remains that they are becoming very popular. One feature of digger ploughs worth bearing in mind is that they will plough deep, deep in relation to the width of the slice. A general purpose plough ploughs satisfactorily up to about two-third as deep as the furrow is wide. A digger cuts a furrow as dee as it is wide. Market gardeners, doing intensive all-seaso cultivations, are using digger ploughing in various soils, bu for general arable work a full digger plough is more favoure on light land than in heavy land and they are selected chiefl where the intention is to plough deep.

One-way ploughs leave the field level, with no openin ridges and no finishing troughs. Ridges and troughs persi through all subsequent cultivations, and can often spoil th smooth passage of harvesting implements. It must no however, be forgotten that in some soils the troughs provid very useful drainage channels. Another advantage is that a the troublesome work of marking out the field and contrivin the openings and finishings is made unnecessary.

Some small one-way ploughs are of the balance type, in which each end has a complete set of plough parts, mouldboard, share and coulter. One set throws the furrow slice to the left and the other to the right. At the end of a bout the implement is tipped over so that the other plough comes into work.

For most tractor drawn one-way ploughs the end-over-end balance principle has not been used. Instead, they are made so that the ploughs revolve through a semi-circle and are locked into their new position. Some horse drawn one-way ploughs were made like this and were called turnabout ploughs.

Directly mounted one-way ploughs are made in several designs. In some the tractor has two quite independent ploughs attached to it, one to throw the furrow slice to the left and the other to the right. Either plough can be put into work at will. Two furrow reversible ploughs of this type for direct attachment to a tractor through 3-point hydraulic lift linkages are popular.

If one-way ploughing is to be done at all, the mounted plough is the way to do it, but not everyone can see great advantages in one-way ploughing, and some consider most of the benefits of a level field can be attained by round and round ploughing starting either from the middle or the outside of the field.

With the increase in the use of combine harvesters, ploughs are having to work in difficult conditions. Long straw stubble from the combine, has to be ploughed in and sometimes the plough has to deal also with the straw ejected from the combine's threshing mechanism. A plough with wavy edged disc coulters, instead of the usual flat disc coulters, can help in this operation. The waves cause the discs to be driven more positively through the soil, and not to skid along without rotating. As long as the disc keeps turning it will cut through the straw satisfactorily. Skim coulters should be used as well.

Another way of helping the burying of the straw is to use a trash guard, which is a pair of spring loaded skids placed one on each side of an ordinary flat disc coulter. The skids hold the straw down firmly so the disc can cut through it without becoming blocked. A home-made version of this trash guard device can be contrived by using a piece of old motor outer tyre, with a slit cut in it for the disc.

Skim coulters cannot be used with trash guards.

Cultivators and Harrows—The disc harrow which is really a light disc plough since the discs are concave and do throw the soil to one side, is widely used for many operations from cutting up grassland and stubble before ploughing, to getting a seedbed after the land has been ploughed. Discs break down the soil without bringing buried plant material to the surface, and this can be of great advantage when cultivating after ploughing. Discs should not be used in land containing perennial weeds.

The old rigid tined cultivator continues to be popular. It is a good example of a real tractor tool for horses were never able to do deep heavy cultivating. Steam cable tackle or a sizeable tractor were needed to make rigid tined cultivators worth while.

There is a revival of popularity in the spring tined cultivator or harrow. The fineness of tilth it can produce, by its vibrating tines, is useful for smooth seed beds.

In the classification of cultivators and harrows can be included also the rotary cultivator, though in some conditions this implement can do also the work now done by ploughing, but, in general, time must be allowed for the weather to work on the soil between being broken up and when made into a seed bed. Tractor power take-off drives have given a very convenient way of operating rotary cultivators. They work quite deep. Wheel grip is no problem, because the work is done through the power take-off. The draught is very low indeed. Wheels are usually adequate, and tracks are rarely necessary. Nevertheless, much power is used and the cultivators move forward, fairly slowly, and although some operations may be telescoped, the total fuel consumption may not be much less than it would be if all the operations were done separately, by plough and tined cultivators and harrows.

Although it is doubtful whether rotary cultivation will ever take the place of ploughing and tine cultivating in field crop work, there is every reason to think that market gardeners find these machines good for stirring the soil after a crop has been lifted, though perhaps the smaller ones will be more popular for this work than the larger ones.

Fixed tine harrows can be classified as follows :—

Zig-zag—Three leaves : 20 tines in each = 60 in all Width covered, 6–7 ft = 1 tine every 1·5–2 in. of width = 6 to 8 per foot width. Tines—To have thick heads or necks where fastened to the frame : small necks with ordinary screw and nut will break easily.

Wheel—Best, as has adjusting handles with spring behind tines, and seat.

Acme or Knife—Valuable for cutting *across* tough ley furrows and preparing seed bed on the same. Disc cultivator does same work, but better.

Rollers. Weight of Rollers—12 cwt. required for ligh land ; 17 cwt. or more for heavy land.

Crosskill or Cambridge weighs up to 28 cwt.

Those with large diameters easiest to draw: 5–7 ft. long and 2½–3 ft. diameter, divided into two or three segments to facilitate turning.

Rollers break up lumps to produce a fine tilth and consolidate the soil for seeds or the soil around roots of young plants. This consolidation makes it easier for seeds or plants to obtain moisture and it also can undo the harmful loosening action which frost or other weather conditions may have had upon the soil holding the seed or young plant.

Mowers and Binders—

Weight of mower, trailer	730 lb.
Weight of binder, trailer	1,600 lb.
Amount of twine used per acre in binding (1 ball)	3–4 lb.
Draught of 5-ft. mower	300 lb.
„ 6-ft. binder	400 lb.

Elevators—Shafts—To be at hopper end, as most suitable for moving, setting up, and taking down.

Hopper—To be as low as possible, or front removed entirely, so that revolving prongs come almost on to the ground to suit sweep-rake.

Height of Delivery—26 and 30 ft. The former is sufficient as the top part of ridge of stack can easily be carried higher by pitching with fork in case of large stacks.

Hay-rick Lifters—Best form is 3 shear-legs; lifts rick of 15–20 cwt. bodily up, so that ordinary cart can be run in beneath to load.

Directly Mounted Implements—3-point Hydraulic Linkage—Advantages are ease of operation, the ability to turn short on the headlands, to reverse without disconnecting, and to run quickly home from the field, and the facility for manoeuvring to work out small plots of land. There is a limit to the size of implement that can be dealt with by direct mounting. A long, heavy implement has too high a moment to make hand lifting possible, or power lifting easy, and to make travel from the field safe. The travel can be helped by a hook to keep the implement raised so as not to rely on the hydraulic mechanism to hold the implement in the fully raised position, but for very large and heavy implements the hydraulic lift, direct mounting principle cannot be used at all. The advantages of hydraulic control of the work can however be retained, even though the implement is trailed on its own wheels. The implement can be lifted out of work, or its depth of work can be regulated by a hydraulic jacking piston and cylinder which receives its pressure oil supply from the hydraulic pump on the tractor. The lift can be operated by a small hand lever in just the same way as the lift of directly mounted implements.

It is doubtful whether trailed implements can ever be superseded entirely by mounted implements for heavy primary cultivations. There can, however, be no doubt about the handiness of direct mounting for inter-row work. Ridging for potatoes is done quickly by tractors with directly attached toolbars, carrying three ridging bodies. The rows are straight, the troughs are smooth and even, and the ridges can be made flat enough on the top for the tractor to ride steadily when the time comes to split the ridges back.

Splitting back needs skill. The wheels of the tractor have to run along the tops of the ridges. Once the wheels begin to slip down into the furrows it is extremely difficult to regain the ridge tops before some seed has been damaged.

Splitting can be greatly helped by making the original ridges flat at the top, and this can be done by setting the ridging plough shallow in relation to width and to angle of mouldboard When the plough is set full depth for any given distance betwee the rows, the peaks of the ridges will be sharp edged and i will be nearly impossible to keep the tractor along their tops When the drills are drawn shallower a flat platform is left a the top, and the tractor can be driven along this path.

A help to keeping on the ridges is an arrangement of bobbin fixed to the front of the tractor to ride on the two ridges.

It often pays, however, when using a 3-row ridger, to split onl two ridges at once, so that only two wheels, one front and on back, are on top of the ridge. The other two are in a troug This method can be used on all runs except the first on

INTER-ROW CULTIVATORS—Mid-mounted hoes are well view of the tractor driver and have the advantage of bein amidships between the front and back wheels and their mov ment is not exaggerated when the tractor is steered. Impl ments amidships, or forward of the front wheels, answer the steering directly. When the tractor turns to the left, th tools turn to the left ; whereas, when the implement is behin it swings at first towards the opposite side to that to whic the tractor is directed but the knack of steering rear toolba can soon be acquired.

Wide toolbars, with a fixed horizontal position relative the tractor, and with the hoes rigidly fixed to the bar, can awkward on uneven land. If the tractor tilts, the hoes on o side of the toolbar go in too deeply, and at the other end of t bar the hoes are too shallow. This is bad agriculturally a also it upsets the steering of the tractor by making the resistan on one side of the tractor greater than the other. Separ articulation of each group of hoes can obviate this unevenn of depth.

For valuable crops a second man is often well worth while, and the directly mounted steerage hoe is one of the most sensible tools invented for the kind of row crop work done in Britain.

TABLE 150

CAPACITY OF FIELD IMPLEMENTS, TRACTOR DRAWN

Implement	Acres per hour
Plough, 2 furrow	½
3 ,,	¾
Cultivator	1
Disc harrow	1
Roll	5
Drill	1½
Fertiliser distributor	1⅓
Mower	1
Swath turner	3
Hay sweep	1
Binder	1½
Combine harvester	1¼
Potato	½
Potato digger	⅓
Potato harvester	¼
Sugar beet harvester	¼

Calibration of Corn Drills and Fertiliser Distributors—Number of turns of wheel required for 1/10-acre

$$= \frac{1{,}400}{\text{Sowing width (in feet)} \times \text{diameter of wheel (in feet)}}$$

To make use of above formula jack up driving wheel, engage drive of mechanism, place sheet under drill or distributor, rotate the wheel through the number of turns given by the formula above, and then weigh the seed or fertiliser deposited in the sheet.

Field Spraying—Gallons per minute per nozzle

$$= \frac{\text{Miles per hour} \times \text{nozzle spacing in inches} \times \text{gallons per acre}}{5{,}940}$$

Output in gallons per acre =

$$\frac{\text{Number of nozzles} \times 11 \times \text{Output per nozzle in galls. per min.}}{\text{Length of boom in yards} \times \text{speed in miles per hour} \times 4}$$

Required pump capacity in sprayer, in gallons per minute

$$= \frac{\text{gallons to be applied per acre} \times \text{speed in m.p.h.} \times \text{length of boom in feet}}{495}$$

If hydraulic agitation of the spray solution is employed, a pump with delivery 20 per cent. greater than is given by this calculation is required.

Choice of Machine—The kind of machine to select depends upon the chemicals to be used, and the quantities to handle. Some spraying compounds are suspensions which usually need to be applied in large quantities of water, while others form true solutions which may be applied at rates as low as 5 gallons per acre. The minimum amount of water needed for the application of a particular spray compound cannot be expressed as a definite figure, regardless of the type of machine used. Thus, one compound may need to be applied at a rate of 100 gallons per acre for satisfactory work with one machine, while another machine which has been particularly designed for handling that type of material may do quite satisfactory work with the same amount of chemical in only 25 gallons.

Some machines are very flexible in output, while others are strictly "high-volume" or "low-volume" machines.

The use of sulphuric acid calls for machines in which the container and pump are made of acid-resisting material, but a point to remember here is that concentrated sulphuric acid has less effect than diluted sulphuric acid.

Many machines are made for direct attachment to a tractor. Some are trailer mounted. The pump is often driven by P.T.O but independent engine drive can be used.

Operation, Care and Maintenance—*Before work*—Chec the machine with water before starting work, in order to se that nozzles are not blocked and are correctly set to give eve distribution.

During work—The rate of application is controlled largel by forward speed. It is therefore essential to check the spee carefully and to keep it constant during operation. Som kind of speedometer is of great benefit in this.

Care must be taken to avoid overlapping or missing, especial when spraying for weed control.

Sulphuric acid, M.C.P.A. and D.C.P.A., are extreme toxic to most root and vegetable crops. With low-volun sprayers especially, it is important to take precautions again the drift of spray on to neighbouring fields, otherwise muc harm can be done. If there is a breeze in the wrong directio spraying should on no account be undertaken.

D.N.O.C. and the phosphorus systemic sprays need ve expert handling and application to get the best results. Mor over, their toxic nature brings considerable risks of injur the health of the operator and of contaminating the cr being treated. Therefore, it is recommended that sprayi by D.N.O.C. and phosphorus solutions should be undertak only by contractors who have the machines and experien essential for efficiency and safety. Many other spray materi are poisonous. The makers' recommendations on handling shou be closely followed. Protective clothing should be worn. No spray must touch the skin. Operators must wash before eating or smoking.

In considering methods of maintaining the efficiency of spraying machines it should be remembered that as time goes on the nozzle jet wears, and this increases the rate of spray.

The suction line strainer should be cleaned frequently, particularly if pond water has been used to make up the spray.

Where the pump is driven from the P.T.O. of the tractor hauling the machine, it is important that the power shaft shall be put out of gear when the outfit is turning on the headland. Rotation of the shaft under load when it has to drive through a sharp angle may cause a breakage.

Once a day the oil level in the crank case of the pump should be checked and all grease points should be attended to.

AFTER WORK—As soon as spraying is finished, clean water should be drawn through the pump and forced out through the delivery hoses and nozzles. Then the tank should be sprayed down. The pump shoud be drained. At the end of the season the machine should be washed, dried and rust-proofed before being stored.

Combine Harvesting. GETTING MACHINE READY—Clean out accumulated rubbish. Grease all nipples and fill all oil baths to proper level.

Put knife in cutter bar and test for smooth travel. Tap down clips if necessary. Try spare knife as well. Make sure all sections are in good order, and all rivets tight.

Turn drum, elevators, fan, shakers and all moving parts by hand to make sure all are running freely.

Fit belts and chains and adjust their tension.

If combine is tractor-drawn, couple to tractor and adjust drawbar to correct height.

OPERATION—Leave the crop till dead ripe—at least a week later than it would be fit to cut with a binder.

Try to cut only in dry weather, and do not start too early in the morning nor continue too late in the evening.

Open out with binder or with combine making its first round with cutter bar away from hedge.

Use revolution counter to set governor of combine engine, or engine of operating tractor, at speed necessary to give required speed to working parts of combine—530 r.p.m. is usual for power take-off shaft.

Do not tighten safety clutches enough to render them ineffective.

Grease all points twice daily. Oil fast moving parts every three hours.

After each period of work run combine empty before stopping.

Water Pumps

Ordinary Dimensions for Hand Pumps—Wells under 30 ft.

Diameter of barrel	4 in.
Length of stroke	10 in.
Quantity of water per min., 20-ft. well.	24 gals.

To be worked by pump handle.

Wells from 30 to 70 ft. :—

Diameter of barrel	3½ in.
Length of stroke	9 in.
Quantity of water per min., 50-ft. well	16 gals

To be worked by fly-wheel and crank.

HORSE POWER REQUIRED—

G = Gallons raised per hour.
h = Total lift in feet.

$$\text{H.P.} = \frac{G \times 10 \times h}{60 \times 33{,}000}$$
$$= \frac{G\,h}{198{,}000}.$$

It is usual to allow from 60 to 80 per cent. additional power to cover loss from friction, leakage, etc.

QUANTITY OF WATER RAISED—

G = Gallons delivered per minute.
L = Length of stroke in feet.
D = Diameter of barrel in inches.
N = Number of strokes per minute.

$$G = \frac{N\,L\,D^2 \times {\cdot}7854 \times 62{\cdot}5}{144 \times 10}$$
$$= N\,L\,D^2\,{\cdot}034.$$

USEFUL NUMBERS FOR PUMPS—

D = Diameter of barrel in inches.
L = Length of stroke in inches.
$D^2 L \times {\cdot}7854$ = cubic inches per stroke.
$D^2 L \times {\cdot}002833$ = gallons per stroke.
$D^2 L \times {\cdot}0004545$ = cubic feet per stroke.
$D^2 L \times {\cdot}02833$ = lb. per stroke.

POWER FOR DEEP WELLS

Galls. of water raised per hour ...	200	350	500	650	800	1000
Height of lift for 1 h.p. engine, in ft.	990	561	396	308	242	198

Wells—Best made with reinforced concrete rings of 3 ft. or more diameter, and each ring 2 ft. deep. Earth is excavated from the interior, and the bottom rings slip gradually down, another ring being fitted on top as they sink. For straight work the four bottom rings ought to be bolted togethe with slips of quartering inside to prevent them from becoming displaced as they sink.

Siphons—Where a well is situated on high ground the water may be siphoned out by a pipe fixed over the edge of the well and down into the water. The long " arm " of the pipe will " suck " the water up over the bend to any height less than 30 ft. and deliver where required at a lower level.

Limekilns—Narrow at mouth and bottom, and wide in middle, as the fire tends to burn through the stone in this form. Width of mouth, 4 ft. ; width of middle, 8 ft. ; width of throat at bottom, 2 ft. ; height of cavity from throat to mouth, 23 ft. The throat to be high enough above the roadway to allow carts to back into it. The above size will burn 120 cubic feet of lime per day, or from 90 to 100 bushels. Best used on land in a finely ground condition.

Where an outcrop of limestone occurs on a farm it can be burnt on the spot in a trench or cavity dug into the side of the sloping ground if wood, peats or brushwood can be readily obtained. Raw unburnt rock can be used on the land if reduced to a fine powder, and disintegrators are to be had for this purpose.

Depreciation and Wear and Tear Allowances—In addition to a basic allowance of 40 per cent. the Inland Revenue authorities permit an annual allowance of five-fourths of the following basic rates of wear and tear :—

	Per Cent.
Steam boilers, engines, portable steam engines, threshing machines (other than peg drum) and fixed plant	5
Electric installations	7½
Petrol or oil driven tractors	22½
Binders, reapers and combine harvesters	15
Sugar beet and potato harvesters and diggers ...	20
Sprayers and flax-pulling machines	25
Commercial motor vehicles (internal combustion)	20
Motor cars (the allowance is restricted to the proportionate part applicable to the car for farming purposes)	20
All other types of farm machinery and implements, including peg drum threshing machines, portable poultry (and similar) sheds and incubators ...	10

Contracting Charges—Minimum charges recommended by British Agriculture Contractors' Association, 1950 :—

Ploughing grassland	30s. per acre.
Ploughing arable land	25s. per acre.
Cultivating (heavy)	10s. per acre.
Cultivating	8s. per acre.

Dragging	4s. per acre.
Spring-tine digging	7s. 6d. per acre.
Pitchpole dragging	8s. 6d. per acre.
Rolling	4s. per acre.
Drilling	17s. 6d. per acre.
Dung spreading	£10 per day for dung loading, plus £2 per hour for 2 tractors and 3 spreaders.
Combine harvesting	65s. per acre, with one operator.
Combine harvesting	£5 per acre, supplying everything.
Pick-up baling, hay and straw ...	27s. 6d. per ton (including twine).

Safety—Before any attempt is made to start the engine of a tractor either by hand crank or electric starter, the operator must satisfy himself that the gear lever is in its neutral position Most cases of a driver being run down by a tractor occur. however, not when the engine is being started but when implements are being connected to the tractor.

There are two rules which must be observed every time a trailed or mounted implement is being hitched. The first rule is that the driver must remain on the seat of the tractor while he is backing it towards the implement. The other rule is tha the gear of the tractor must be put into neutral before th driver dismounts ; he should not rely upon the clutch bein held out by a catch while the gear is left engaged.

The tractor should be backed very slowly towards th implement. If a second man is available he can hold the hitcl of the implement ready for the clevis to engage the tracto drawbar, or he can guide the arms of a unit attachment imple ment, but this second man must not kneel or crouch at the job He must be on his feet in such a position that he can move awa quickly if things go wrong.

A great help to a tractor driver who has to connect a traile implement on his own is an iron hook on a long handle, to b used like a railway shunter's hook. The driver backs th tractor until he is near the implement. Then, still seated in th tractor, he leans back and with the hook lifts up the impleme drawbar and holds it so that the clevis will engage with th tractor drawbar when he eases back the tractor the last fe inches.

There is a danger of the tractor toppling sideways when it driven too near the crumbling side of a ditch, or when it put to work on extreme sideling land. Another cause overturning is the use of one back wheel brake instead of bot

Independent brakes are provided to help the tractor to turn when it is running slowly on a narrow headland, but to check the tractor when it is running fast on the roadway or from field to field, the brakes must be applied on both rear wheels simultaneously. If only one rear brake is applied it may swing the tractor to one side and cause it to overturn.

Power-take-off drives should generally be stopped before the driver dismounts from the tractor, and at any rate no adjustments to implements should be attempted until it is quite certain that the power drive is disengaged.

Ground wheel drive machines must always have their mechanism put out of gear before any attempts are made to adjust them. For example, when a mowing machine is in gear only a very small movement of the machine along the ground is sufficient to work the knife enough to bring injury to anyone who may be clearing grass that has bunched on the fingers of the bar. Even when the machine is out of gear, the operator should always stand behind the cutter bar and not in front of it, and he should use a stick to push the grass from between the sections

Belts, chains, gears and moving canvasses should never be touched at all until they have come to rest and until they are disconnected from any possible source which might impart movement to them.

Guards and shields, such as the covers on a power-take-off shaft, should always be firmly in position while the machine is at work. It is worth while to make some covers for parts of machines not already guarded. Belts driving elevators and other machines on the field can have some temporary guard rigged up, even if it consists of only a few stakes driven into the ground to prevent people falling on to the belt if they stumble.

In a circular saw a dull blade is more dangerous than a correctly sharpened one. Great pressure has to be applied to make a dull blade cut, and therein lies danger. Guards should be set as close to the edge of the blade as possible and as near down to the bench as the work allows. It is well not to stand directly in the line of the saw, since wooden particles, or the parts of a broken blade, follow the line of cut. Sawdust should be removed only when the saw is stationary. The operator should never reach across the saw when it is working and risk bringing himself or his clothing near the working blade.

For working at a saw bench, and indeed for working with any other machinery in motion, the operator ought to wear close fitting overalls ; a flapping coat is a danger. Loose ends of clothing can catch in moving parts and wrap round them in an instant.

Safety in the use of electrical appliances depends mostly on the installation itself having been made soundly ; but the user must take good care of any flexible wires in the circuit. Abrasion and heat soon destroy their insulation, and jerks and pulls tear the ends of the wire out of the connectors. Extension cords must not be bent at too sharp an angle. They should never be looped over nails. No weight or pull should be borne by the connection of a flexible wire in a plug or in a lampholder or other appliance, and when a plug is to be disconnected from a wall socket, the plug itself should be pulled and not the wire.

Goggles should be worn at threshing time and when cultivating dusty fields or handling noxious chemicals ; a comfortable, well ventilated pair of goggles, fitted with unsplinterable glass, is a most effective protection against the discomfort and minor injuries that can come from getting grit in the eyes.

Threshing machines should be well guarded to prevent the possibility of the operator feeding the sheaves falling into the drum. The band cutting knife can be tied to the wrist of the operator so that should the knife slip from his grasp he will not need to move to pick up the knife and risk losing his balance.

TABLE 151

ESTIMATE OF PRINCIPAL IMPLEMENTS AND MACHINES REQUIRED IN A MIXED HUSBANDRY FARM

Implements and Machines	Ac. 100	Ac. 150	Ac. 200	Ac. 300	Ac. 500	Ac. 800
Carts — one-horse, with tractor drawbar attachment	2	3	4	5	6	8
Wagons or 4-wheel trailers	1	1	1	2	2	3
Liquid manure cart ...	1	1	1	1	1	1
Tractor tool bars... ..	1	1	2	2	3	3
Iron rollers	1	1	1	1	2	2
Horse-hoes	1	1	1	1	1	2
Fertiliser distributors ...	1	1	1	2	2	3
Ploughs (tractor) ...	1	2	2	3	4	5
Double-mouldboard ploughs (direct mounted)	1	1	1	1	2	2
Light grass harrows and chain harrows : each	1	1	1	1	1	2
Heavy seed harrows ...	1	1	2	2	3	4

Implements and Machines	Ac. 100	Ac. 150	Ac. 200	Ac. 300	Ac. 500	Ac. 800
Disc cultivators	—	1	1	1	1	2
Combine drills	1	1	1	1	1	2
Grass seed drill	—	—	1	1	1	1
Drag-harrows	—	—	1	1	1	2
Binders	1	1	—	1	1	1
Mowers	1	1	1	1	2	3
Combine harvesters ...	—	—	1	1	1	2
Horse-rakes	1	1	1	1	2	3
Hay sweeps	1	1	1	1	2	2
Hay loaders (universal, for short and long grass)	1	1	1	1	1	2
Elevator	1	1	1	1	1	1
Potato spinners	—	—	1	1	1	2
Chaff cutter	1	1	1	1	1	1
Root cutters	1	1	1	1	2	2
Winnowing machine ...	—	1	1	1	1	1
Grinding mill	1	1	1	1	1	1
Oilcake breakers ...	1	1	1	1	2	3
Pick-up balers	—	—	—	1	1	1
Tractors light and medium) wheeled	1	2	2	3	3	3
Tractors (heavy) track-layer	—	—	—	—	1	2
Potato planters	—	—	—	1	1	1
Grain driers	—	—	1	1	1	1
Potato elevator diggers ...	—	—	—	1	1	1

Agricultural Machinery Census—Estimated numbers of implements and machines owned at census date of January, 1950, by occupiers of agricultural holdings, agricultural contractors and County Executive Committees :—

TABLE 152

ENGLAND AND WALES

Machine or Implement	Number
POWER AND HAULAGE	
Tractors :	
Tracklayers, over 6 h.p.	13,460
Three- and four-wheeled tractors	245,400
Total agricultural tractors	258,870

Hay rakes	179,470
Hay sweeps	95,740
Hay loaders	28,960
Hay, corn and straw elevators	55,290
Binders	120,220
Combined harvester—threshers	10,120
Green-crop cutter—collectors...	1,140
Green-crop loaders	4,100
Silage cutters and blowers	1,220
Potato spinners	59,610
Potato elevator, diggers and shaker-diggers ...	9,640
Complete potato harvesters	480
Sugar-beet ploughs, lifters and lifting attachments	30,880
Sugar-beet toppers	1,460
Sugar-beet lifter-cleaners	1,470
Complete sugar-beet harvesters (combined topper, lifter and cleaner)	840
BARN AND FARMYARD	
Portable threshing machines with drum width 2 ft. 3 in. or over	13,940
Hay and straw balers :	
Stationary	7,280
Pick-up	5,020
Loaders (other than hay and green-crop) :	
Tractor-mounted, fork type	1,060
Tractor-mounted jib type	340
General-purpose, elevator type	2,240
Root cutters and pulpers	130,250
Potato sorters :	
Hand (not riddles)	23,580
Power	12,320
Grinding mills : power operated	81,850
Hammer mills :	
5 h.p. and under	4,880
Over 5 h.p.	13,590
Meal mixers	1,730
Grass driers	660
Grain driers	1,310
Winnowers and cleaners, power-operated ...	7,900
Shearing and clipping machines	48,700
DAIRYING	
Milking machines :	
Bucket, one and two units	28,240
Bucket, three and more units	35,530
Releaser or recorder, one and two units	1,550
Releaser or recorder, three and more units ...	3,850
Total milking machines	69,170

Tracklayers, 6 h.p. and under	3,080
One- and two-wheeled tractors	33,310
Total horticultural tractors	36,400
Petrol and oil engines	199,170
Electric motors	82,920
Wagons and carts	403,930
Lorries and vans	90,390
Liquid manure carts	12,180
Tractor trailers	221,070
Spraying machinery :	
Power fruit sprayers	8,030
Wheeled and tractor-mounted ground crop sprayers	4,190
TILLAGE AND CULTIVATION	
Mouldboard ploughs :	
Horse, one-, two- or three-furrow	137,880
Tractor	263,670
Ridging ploughs :	
Horse	115,170
Tractor	63,100
Cultivators, grubbers or scufflers :	
Horse	95,950
Tractor	139,830
Hoes :	
Horse	153,190
Tractor	40,290
Harrows :	
Disc	70,180
Spring tooth	84,520
Others	386,560
Rollers	212,980
SOWING AND FERTILISER DISTRIBUTING	
Corn drills	91,340
Combined seed and fertiliser drills	23,880
Root drills	87,170
Broadcasters, horse- and tractor-drawn	13,790
Fertiliser distributors over 5 ft. wide	88,450
Potato planters	10,970
Seedling transplanters	5,260
HARVESTING	
Mowers, over 3 ft. wide :	
Horse	107,620
Tractor	107,490
Side rakes and swath turners	130,240
Hay tedders	46,240

Sterilising installations :	
Electric	12,100
Other	35,040
Milk coolers :	
Refrigerated	23,730
Other	85,670

SCOTLAND

Machine or Implement	Number
Tractors :	
Tracklayers, over 6 h.p.	1,400
Tracklayers, 6 h.p. and under	230
Three- and four-wheeled	32,970
One- and two-wheeled	2 250
Total tractors	36,850
Ploughs :	
Horse, one-, two- or three furrows	39,570
Horse, one-furrow	10,500
Horse, two-furrows	26,320
Tractor, three-furrows	3,170
Tractor, four-furrows and over	530
Total ploughs	80,090
Petrol and oil engines :	
2 h.p. and under	12,920
Over 2 h.p. but not exceeding 6 h.p.	10,280
Over 6 h.p.	4,860
Disc harrows	11,960
Cultivators, grubbers or scufflers :	
Horse	29,290
Tractor	22,150
Corn drills	9,290
Combined seed and fertiliser drills	1,450
Fertiliser distributors (over 5 ft. wide)	20,850
Potato spinners	14,440
Potato elevators, diggers and shaker diggers	3,670
Mowing machines over 3 ft. wide :	
Horse	19,310
Tractor	11,380
Hay rakes	24,980
Side rakes and swath turners	9,230
Hay tedders	2,410
Hay sweeps	15,030
Hay loaders	2,080

Hay, corn and straw elevators	1,540
Binders :	
Horse	13,430
Tractor	16,790
Power fruit sprayers	180
Portable threshing machjnes	2,330
Combined harvester-threshers	420
Hay and straw balers :	
Stationary	640
Pick-up	260
Milking machines :	
One and two units	2,650
Three units and over	6,930
Sterilizing installations	6,430
Tractor trailers	34,090

FARM BUILDINGS

Siting—Farm buildings should be erected on a warm, open, well-drained site, with preferably a south-eastern aspect, permitting the easy disposal of surface water and farm drainage. Availability of services and access to the public highway must be considered, so that farm roads, which are expensive to construct and maintain, can be kept to a minimum. The homestead, or farmhouse, is usually best sited to the west of the steading.

The actual buildings, forming the steading depend upon the type of farming practised. It is desirable for all livestock and feeding stuffs to be kept to the south of the road running through the farm with the Dutch barns, implement sheds, corn and grass drying buildings, fertilizer stores, etc., on the north side.

The U.E. or T plans used by our forefathers still have much to commend them. In each of these plans the higher buildings are kept to the north—barns, granary, mixing house and open sheds, running from east to west and the cow-house and other livestock buildings at right angles in one, two, or three ranges north to south, thus giving yards which can be covered or open to the south with buildings on two or more sides.

For the comfort of workers routes should be short and under cover if possible.

COW-HOUSES

A single range cow-house without feeding passage should be not less than 14 ft. 6 in. wide, made up as follows :—

Standing and manger ...	7 ft. 6 in.
Dunging channel ...	3 ft. 0 in.
Gangway	4 ft. 0 in.

When a feeding passage is provided it should not be less than 3 ft. wide.

A double range cow-house is more economical of labour for herds of more than 16–20 cows and should be not less than 27 ft. wide. The dimensions given for a single range cow-house apply except that the central gangway should be 5 ft. wide. Where feeding passages are provided, the minimum internal width will be 32 feet. The cows should be ranged facing the outside walls, i.e., tail to tail. Floor area per cow 50 ft. super. Cubic capacity 500 ft. per cow.

Roof Lights, are necessary to a double range cow-house, and should provide at least 3 ft. super of glass area per cow. When windows are provided they should be of the hopper type opening inwards and have a glass area of at least 4 ft. super per cow.

Stall Divisions—Can be of precast reinforced concrete or of tubular steel. The latter are the most popular allowing freer air circulation. Stalls for two cows should be not less than 6 ft. 6 in. wide for the smallest breeds or 7 ft. for average cows. Single stalls should not be less than 4 ft. wide. The divisions should be not less than 3 ft. long from the curb of manger and 3 ft. high. When tubular stalls are installed a small concrete curb immediately under the stall prevents the standards rusting, confines the bedding to the standing and prevents injury to the cows.

Mangers—Can be of concrete cast *in situ*, pre-cast concrete, or glazed stoneware. Many concrete mangers have glazed stoneware linings. Stoneware is more sanitary than concrete. The width of the manger varies from 1 ft. 6 in. to 3 ft. depending upon the type of tie. With yoke or other central tie with its axis on the centre of the front curb of the manger the wider manger is necessary.

The front curb of the manger should not be more than 6 in. in height above the standing and the back of the manger 2 ft. to 2 ft. 6 in. high above the level of the feeding passage. Mangers can be continuous or divided into sections for each cow. The latter, preventing a cow poaching from its neighbour, is desirable.

Individual mangers in the form of glazed stoneware sinks set in concrete are favoured by some ; others prefer removable feeding tubs either of wood or metal for ease of rationing. When tubs are used only a small curb or sinking to prevent undue movement of the tubs is necessary. Half round glazed stoneware channels set in concrete are frequently used as mangers. They should be not less than 15 in. in diameter, with a concrete curb on the standing side and the back splayed up in concrete to the wall of the feeding passage or outside wall of the cow-house.

Adequate space over the manger must be allowed for the horns of a cow. Where separate standings are provided for each cow some farmers prefer to dispense with a manger entirely. Sweep-in mangers having the feeding passage level with the back of the manger are extensively used on the Continent and in the U.S.A. They are gaining favour in this country and have much to commend them. The feeding passage and top of the manger should be approximately 10 inches above the level of the standing.

Hay racks at a high level are not recommended in any farm buildings.

Standings—The cow standing should be impervious and insulated. It should have a fall of at least 1½ in. from the front curb of the manger to the dunging channel. A slight sinking ¾ in. deep and 16 in. to 18 in. wide running parallel with the curb of the manger is recommended. It prevents the cow slipping when rising and prevents the bedding straw slipping back into the dunging channel. The surface of the standing should be roughened (but not grooved) to provide a good foothold, with the last 6 in. to 9 in. of the standing next the dunging channel smooth. Hollow partition blocks, a sheet of corrugated asbestos or land drain pipes placed close together with a topping of 2 in. of fine concrete provide satisfactory insulation.

Dunging Channels—Dunging channels are recommended 3 ft. wide with a 6 in. minimum step up to the standing and a 2 in. step up to the back walk or gangway. There should be an inch fall away from the standing and a cross fall of ½ in. per cow in the length of the dunging channel. The channel should have a smooth finish with the internal angles coved. Provided there is abundant use of litter to fill the channel a narrower and deeper channel as used on the Continent and in the U.S.A. is satisfactory as the liquid manure is absorbed into the straw. Such an arrangement overcomes many drainage difficulties. In this case the dunging channel can be from 16 in. to 18 in. wide with a 5 in. minimum step up to the gangway. Such channels are necessary when mechanical gutter cleaners are used.

Gangways—The gangway should be roughened and have a fall of 1 in. towards the dunging channel.

Floors—Floors generally should be impervious—smooth enough to be easily cleaned but not liable to become slippery. Concrete is the most satisfactory material. This should be laid on a good bed of hardcore 4 in. to 6 in. thick or as site conditions dictate. A thickness of 4 in. is sufficient. If there is a natural fall in the site, economy can be exercised by allowing the cow-house floor to fall with the ground.

Height—All cow-houses should have a minimum height of 8 ft. from the floor to the underside of the tie beam or to the top of the wall plate. This gives approximately 500 cubic feet capacity per cow in a cow-house without a feeding passage.

Drainage—All drains within the cow-house should be of the surface, open-channel type. Where channels pass traffic routes they can be covered with removable cast iron or heavy gauge perforated sheet metal covers and cross channels need only be 12 in. wide. The channels should discharge on to external trapped gullies.

Liquid manure should be conserved and taken to a liquid manure tank. Washing down water should be taken to a suitable outfall by means of an independent drain. For this purpose two gullies can be placed side by side with a removable cover which can be placed over whichever gully is not in operation. Normally it will be kept over the gully taking the washing down water.

With a narrow dunging channel adequately filled with straw as previously stated it is contended that separate gullies are unnecessary as most urine is carted out with the manure and litter direct to the dungstead.

Water Supply—Individual drinking bowls are desirable. They should be placed 2 ft. above the level of the standing. Stand pipes should be provided in a cow-house at suitable points with a hose connection for washing down.

Walls—Stone, brick or concrete are suitable materials for walls provided they are weatherproof and give a smooth surface on the inside of the building. A damp-proof course is necessary in all walls. The upper part of walls can be of suitable framing covered with asbestos above a minimum height of 4 ft. 6 in. All internal angles within a cow-house should be coved and the jambs of doors are best finished with bull-nosed bricks. Piers where unavoidable should be on the outside of the walls. The rendering of all the internal walls of a cow-house to a height of 4 ft. 6 in. is recommended.

Roofs—Roof trusses can be of steel, aluminium, timber or precast reinforced concrete. There should be as few members as possible in the case of steel trusses for ease of painting and to avoid lodgements for dust and cobwebs. Aluminium roof trusses are now available and have obvious advantages but are more expensive. Traditional roof coverings are satisfactory but more costly than corrugated asbestos sheets. Corrugated asbestos sheets with a smooth underlining for ease of cleaning are ideal and allow better insulation. For this type of roofing purlins must be provided at not more than 4 ft. 6 in. centres. Cedar shingles are light and very satisfactory but should be laid at a pitch of not less than 30°. Galvanised iron and thatch are not recommended for buildings housing livestock. Thatch gives a comfortable building and is picturesque, but is inflammable and liable to harbour pests.

Gutters—Eaves gutters with an adequate number of rainwater pipes with shoes discharging over gullies connected to drains and taken to a suitable outfall are necessary to all farm buildings unless rainwater is to be conserved for use on the farm.

Cast iron, galvanised pressed steel of not less than 14 gauge, asbestos, or aluminium alloy, are suitable materials. Half-round eaves gutters should be of not less than 4½ in. in diameter and rainwater pipes not less than 3 in. in diameter.

Cast iron is durable but needs constant painting. Asbestos is almost as strong but tends to get brittle with age. Sheet steel gutters and down pipes should always be galvanised and unless of heavy gauge are liable to bend if ladders are put against the gutters during roof repairs or painting. Cast aluminium alloy is durable and although more expensive in the first instance, needs no painting.

Ventilation—Fresh air inlets should be provided to all cow-houses and placed 1 ft. to 2 ft. 6 in. above the floor level. The baffled type is best where the manger is against an outside wall. One inlet say 9 in. by 6 in. for each pair of cows is considered satisfactory. Outlet ventilation is necessary at the ridge and is more important than the inlets. Outlet ventilation can be provided by ventilating ridge cappings or by a continuous opening say 3 in. to 4 in. wide along the whole length of the ridge. A satisfactory arrangement is a 4 in. to 6 in. plain pipe outlet without a cover. One to each double standing is sufficient in most cases.

Adjustable ridge ventilators are favoured by some farmers. The gearing must be properly attended to or it is apt to get out of action.

Opening windows of the hopper type with cheeks provide good ventilation and where possible centre hung casements in the gable end of a building are desirable.

Artificial means of ventilation by electric fans are sometimes installed.

Lighting—Electricity is the best means of artificial lighting but where neither electricity nor gas is available portable lights of the paraffin pressure type, if properly serviced, are satisfactory.

Lights should be over the back-step of the dunging channel or, in the case of a double range cow-house, in the centre of the gangway usually suspended at each roof truss.

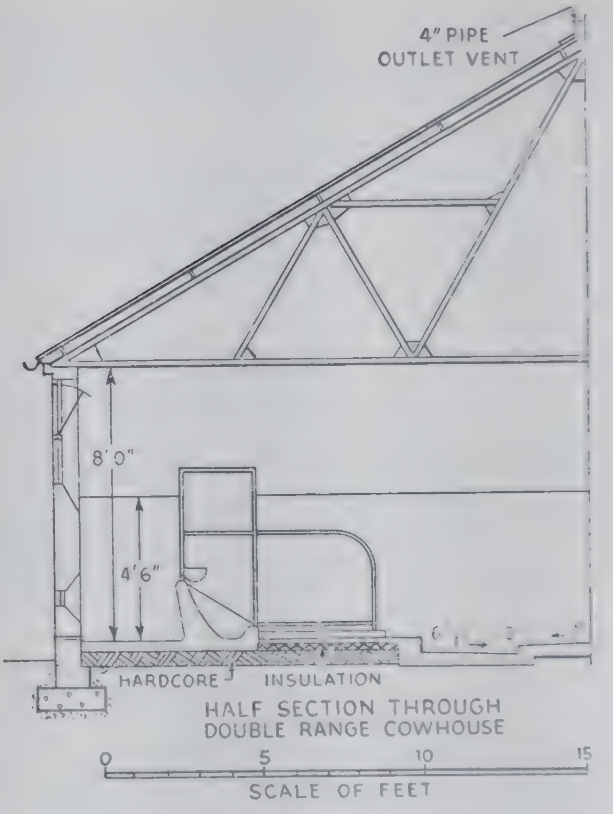

4" PIPE
OUTLET VENT
8'0"
4'6"
HARDCORE
INSULATION
HALF SECTION THROUGH
DOUBLE RANGE COWHOUSE
0
5
10
15
SCALE OF FEET

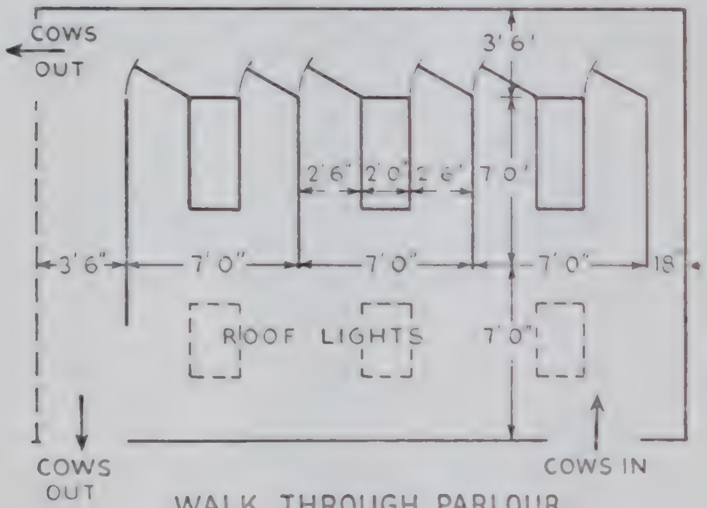
Fig. 14

MANURE DISPOSAL—Manure pits should be sited well away—preferably 60 ft.—from the dairy, cow-house, or other buildings housing stock. They are best formed of concrete with the floor about 3 ft. below ground level with a grooved slope down to it, and surrounded on three sides by a dwarf concrete wall about 3 ft. high above ground level. Manure pits should be roofed and have a capacity suited to the size of the herd, frequency of emptying, and according to the amount of litter used.

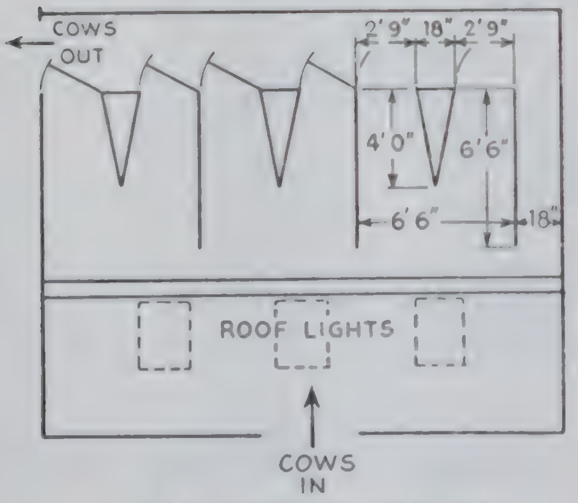
Farmyard manure weighs from 12 to 16 cwt. per cubic yard and each head of cattle produces approximately 16 tons of manure per annum in a well strawed yard.

MILKING PARLOURS—These are principally used in connection with yards covered or partly covered. Milking parlours are of various kinds, the principal being the *walk* *through*, *back out* and the *tandem*. The type of milking to be adopted—hand, bucket, or releaser plant—determines the type of parlour.

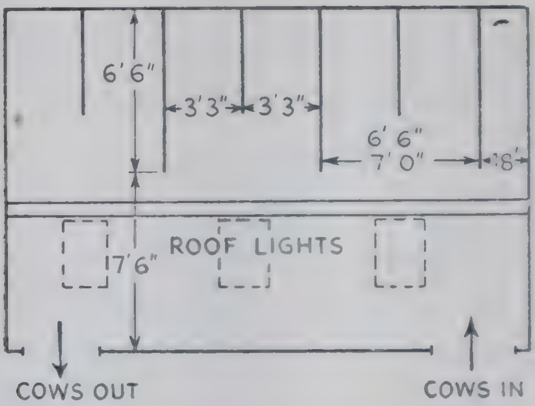
Various forms are shown in the following diagrams which are self-explanatory.


COWS OUT
3' 6"
2' 6"
2' 0"
2' 6"
7' 0"
3' 6"
7' 0"
7' 0"
7' 0"
18"
ROOF LIGHTS
7' 0"
COWS OUT
COWS IN

WALK THROUGH PARLOUR
Fig. 15a

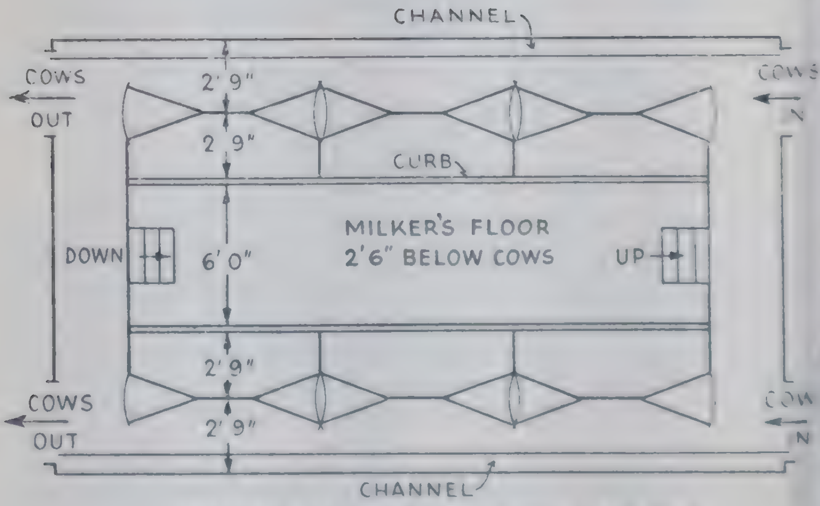

COWS OUT
2' 9"
18"
2' 9"
4' 0"
6' 6"
6' 6"
18"
ROOF LIGHTS
COWS IN

WALK THROUGH PARLOUR
Fig. 15b


6'6"
3'3"
3'3"
6'6"
7'0"
18'
ROOF LIGHTS
7'6"
COWS OUT
COWS IN

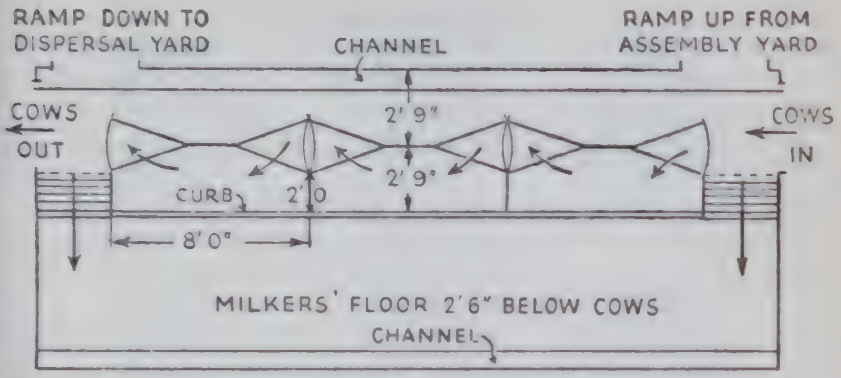
BACK OUT PARLOUR

Fig. 16


CHANNEL
COWS OUT
2'9"
2'9"
CURB
MILKER'S FLOOR
2'6" BELOW COWS
DOWN
6'0"
UP
2'9"
2'9"
COWS OUT
CHANNEL

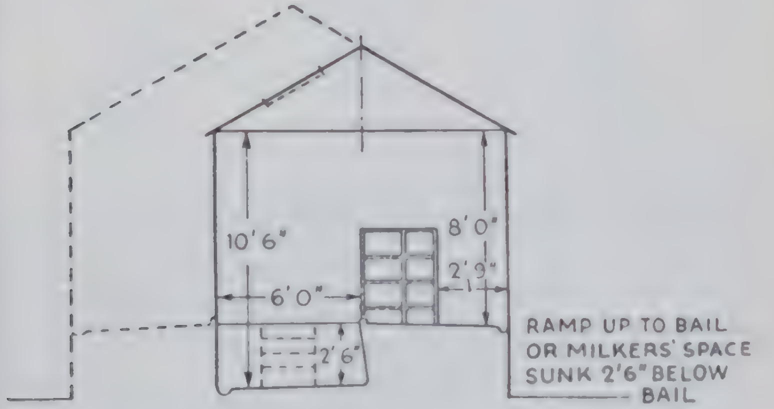
DOUBLE TANDEM MILKING PARLOUR

Fig. 17


RAMP DOWN TO DISPERSAL YARD
CHANNEL
RAMP UP FROM ASSEMBLY YARD
COWS OUT
COWS IN
2' 9"
2' 9"
CURB
2' 0
8' 0"
MILKERS' FLOOR 2' 6" BELOW COWS
CHANNEL

TANDEM MILKING PARLOUR

Fig. 18


10' 6"
8' 0"
2' 9"
6' 0"
2' 6"
RAMP UP TO BAIL OR MILKERS' SPACE SUNK 2' 6" BELOW BAIL

SECTION THROUGH TANDEM MILKING PARLOUR

Fig. 19

In the two level type the milkers' space should be 30 in. below the level of the cows. It is usually better to allow the cows to walk up a ramp to the bails rather than put the milkers' space below ground level.

Special washing stalls are optional but many dairy farmers prefer to wash the cows in the stalls where they are to be milked to prevent undue movement during milking time.

There must be a clean approach to the milking parlour.

Sterilising Chests

Height	Width	Depth
2 ft. 0 in.	3 ft. 0 in.	2 ft. 0 in.
2 ft. 6 in.	3 ft. 0 in.	2 ft. 2 in.
3 ft. 0 in.	3 ft. 0 in.	3 ft. 0 in.
4 ft. 4 in.	4 ft. 0 in.	3 ft. 0 in.
3 ft. 0 in.	4 ft. 0 in.	4 ft. 0 in.
4 ft. 0 in.	3 ft. 0 in.	4 ft. 0 in.

Washing Troughs

Length	Width	Depth
3 ft. 6 in.	2 ft. 3 in.	1 ft. 6 in.
4 ft. 0 in.	2 ft. 3 in.	1 ft. 6 in.
6 ft. 0 in.	2 ft. 3 in.	1 ft. 6 in.

Milk Churns

Capacity	Height	Diameter
4 gal.	20½ in.	10½ in.
6 gal.	21 in.	12 in.
8 gal.	22½ in.	13½ in.
10 gal.	24 in.	14½ in.
12 gal.	27½ in.	14½ in.
15 gal.	28½ in.	16 in.

FARM DAIRIES—These should have a northern aspect and be sited as near as possible to the cow-house but clear of sources of contamination. There must be no direct access from the cow-house to the dairy. Lighting and ventilation are important features. Adequate height should be given, say 9 ft. from floor to ceiling. To obviate undue condensation, ridge ventilation should be provided and the ceiling should be insulated Concrete flats over dairies are not good.

For small herds, say 12 to 16 cows, a single compartment fo handling the milk and washing and sterilising the utensils i permissible.

Unless gas or electricity is used for heating water the boile must be in a separate compartment with no direct approac from the dairy. For larger herds separate compartments shoul be provided, one for handling the milk and the other fo washing and sterilising utensils. The size of the compartment depends upon the size of the herds and the amount of fixe equipment to be used.

The tipping lobby must be well lighted and ventilated wit provision for observing the state of the churns being fille Twenty-five square feet is a reasonable minimum size for th tipping lobby. It should be provided with a lavatory basin.

Steps up to the milk hopper should be 1 ft. 8 in. high. Cooling milk by the normal water method requires three to six gallons of water to cool one gallon of milk.

The chilled water, chilled brine and direct refrigeration systems do not require so much water, while the churn immersion cooler is coming much more into use. These systems require electricity.

The following table gives the sizes of Milk Room and Washing and Sterilising Rooms for various sized herds.

TABLE 153

Size of Herd	Milk Room	Washing & Sterilising Room	Boiler House
Up to 20 cows ...	80	100	30
20 to 40 cows ...	80–120	100–150	40
Over 40	100–150	150–200	50

All walls, unless lined with tiles, should be rendered smooth in cement.

Floors should be laid to fall to an open channel discharging outside the building. Floor finishes should be hard wearing, and impervious. Granolithic paving or blue bricks laid and grouted in cement have proved satisfactory but purpose made perforated cast iron panels for filling in with granolithic withstands the rims of churns as well as anything.

Loading banks should be 3 ft. high.

Sterilising chests should be placed as near as conveniently possible to the boiler to prevent undue lengths of pipe and consequent heat loss.

BULL BOXES—Should not be less than 150 ft. super in area with a pen approximately twice that size. The box should have a height of not less than 8 ft. to the wall plate. Door openings should be 4 ft. wide by 7 ft. high in the clear.

Dwarf walls to pen 3 ft. 6 in. high with rails over, permit the bull to see out without the risk of his levering the rails. Spacing of rails 6 in. to 8 in. apart. The floor of box should be kept well above the surrounding ground level with a fall towards the door opening. A 2 in. to 3 in. step down from box to pen is necessary. Escape gaps 10 in. to 12 in. wide should be provided from pen.

Trough 2 ft. 6 in. high with drinking bowl arranged to prevent the bull getting his horns under. Windows should be out of reach.

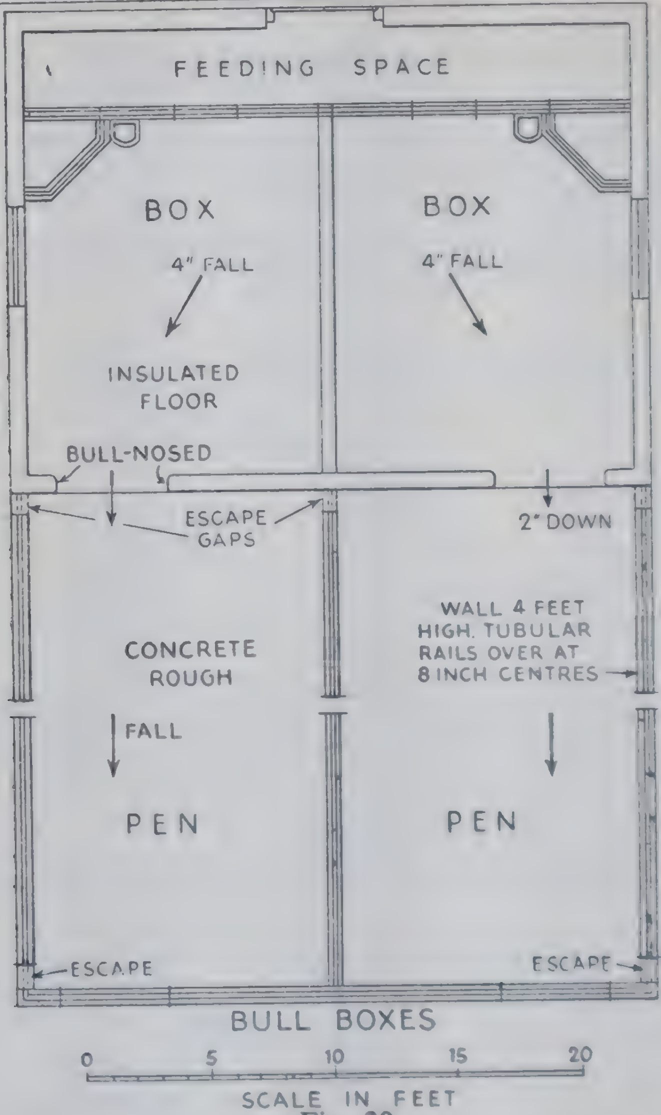
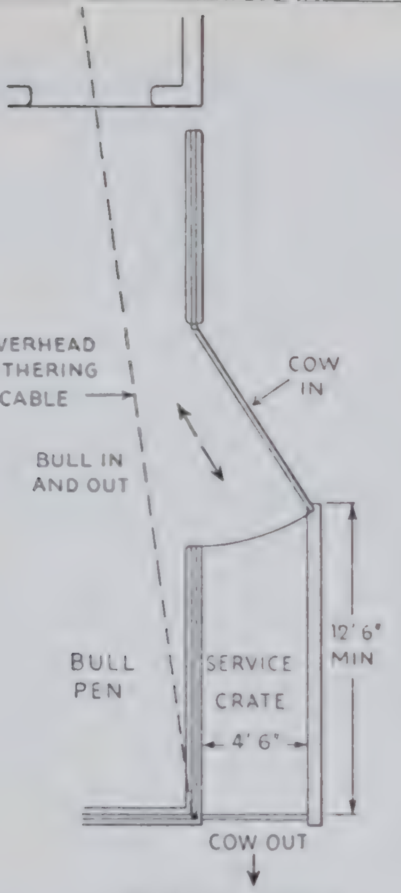

FEEDING SPACE
BOX
BOX
4" FALL
4" FALL
INSULATED FLOOR
BULL-NOSED
ESCAPE GAPS
2" DOWN
WALL 4 FEET HIGH. TUBULAR RAILS OVER AT 8 INCH CENTRES
CONCRETE ROUGH
FALL
PEN
PEN
ESCAPE
ESCAPE
BULL BOXES
0
5
10
15
20
SCALE IN FEET

Fig. 20

Service crates---Should be 12 ft. 6 in. long and approximately 4 ft. 6 in. wide with standing space for the cow 24 in. wide. The foot boards for the bull should start at 15in. in height rising to approximately 3 ft. 9 in. in a length of 7 feet. The sides of the crate should be smooth to prevent injury to the animals. Alternative methods of arranging them in connection with Bul pens are shown below.


OVERHEAD
TETHERING
CABLE
COW
IN
BULL IN
AND OUT
BULL
PEN
SERVICE
CRATE
12' 6"
MIN
4' 6"
COW OUT

SERVICE CRATE Fig. 2

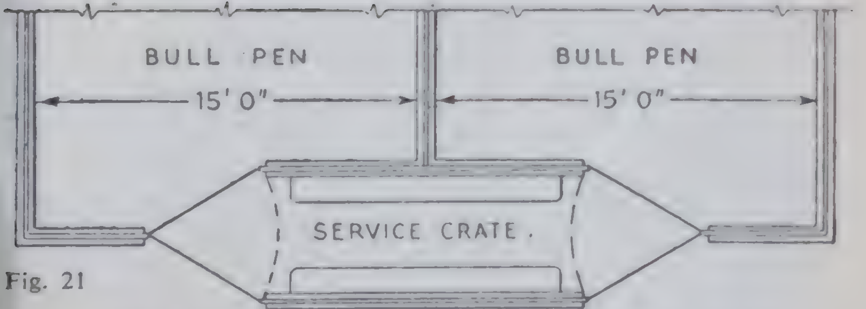
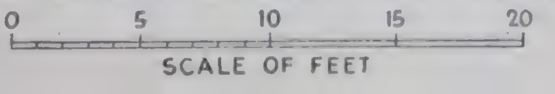

BULL PEN
15' 0"
BULL PEN
15' 0"
SERVICE CRATE.

Fig. 21

SERVICE CRATE TO OPERATE FROM TWO PENS


0
5
10
15
20
SCALE OF FEET

Isolation Boxes—Are best away from other buildings, or if with them, so arranged that the animals can be fed and watered without passing through yards, etc., holding other stock.

A separate drainage system is desirable.

All internal angles should be coved and the walls rendered to facilitate cleansing. Light and ventilation are important. An R.S.J. or beam across the centre of the box at plate level enables an animal to be slung if necessary on occasions. Tying rings should be provided in two or three positions for securing animals during examination or operations.

CALF PENS—Buildings for housing calves should be well sheltered, airy but cosy, with a well insulated roof and floor. Sunlight and shelter to the yards is important.

Calves up to three months should be kept in single pens having a superficial floor area of approximately 24 square feet. Older calves can be run in groups of three or four in pens twice this size. Pen divisions should be 3 ft. 6 in. high solid, and preferably removable but the fronts of pens are probably best of tubular steel so that the calves can look out.

Unless young calves are to be suckled it is desirable that the calf house should be within reasonable distance of the dairy.

If loose boxes are to be used for housing calves it is an advantage if the half hack doors are interchangeable so that the upper half of the door can be hung as the lower half. This admits more sun and air into the box and enables the calves to look out without straining. Gates to pens should be 2 ft. wide.

When calf pens are on both sides of a centre passage it is convenient to give the floor of pens a 3 in. fall to a shallow gutter on either side of the passage which in turn discharges on to an external gully.

There is a divergence of views on the amount of light necessary but the general opinion is that the glass area of windows should be approximately 1/20th of the area of the calf house.

Baffled fresh air inlets and ridge ventilation must be provided but draughts must be avoided.

For larger calves drinking bowls are desirable.

DUTCH BARNS—These are made in various widths (or spans) of from 18 ft. to 45 ft. and 16 ft. to 22 ft. high to eaves The normal bay is 15 ft. and the length will therefore be determined by the number of these units.

A standard Dutch barn 16 ft. high to eaves and of 30 ft. span will hold approximately 1 ton 12½ cwt. of hay or 1 ton 1¼ cwt. o straw and will have a capacity of approximately 600 cubic fee per foot run.

Stanchions for this size of barn should not be less than 7 in. by 4 in. R.S.J's.

Gables should be cladded down to eaves level and can be provided with pitch hole doors. In exposed positions they may be cladded partly or wholly down to ground level on one or more sides.

Eaves projecting 2 ft. or 3 ft. beyond the face of the stanchions are an advantage as providing greater protection to the crops. The roofs if covered with galvanised iron should not be less than 22 gauge with cladding of 24 gauge.

Corrugated asbestos is sometimes used but is liable to fracture. Trusses and stanchions must be more rigid when asbestos is used.

Adequate eaves gutters and down pipes must always be provided and the rainwater must be carried to a suitable outfall. The concrete at the feet of stanchions should be benched up above the finished ground level at least 6 in. The floor within the barn should be slightly above the surrounding ground level.

Reinforced concrete Dutch barns covered with corrugated asbestos are favoured by some. Spurs or bollards should always be provided at the feet of concrete stanchions to prevent vehicles fracturing them.

Steel stanchions are usually set in concrete 3 ft. by 3 ft. by 3 ft. deep but sometimes bolted at ground level to concrete foundations.

Where two barns run parallel to each other with a covered way between them the covered way should not be less than 12 ft. wide.

Dutch Barn Stanchions. Recommended Sizes.

Height to eaves (ft.)	Cross section Up to 20 ft. span	Over 20 to 25 ft.	Over 25 to 30 ft.
16 ...	6 in. by 3 in.	7 in. by 3½ in.	7 in. by 4 in.
16 to 18	7 in. by 4 in.	7 in. by 4 in.	7 in. by 4 in.
18 to 22	8 in. by 4 in.	8 in. by 4 in.	8 in. by 4 in.

CORN DRYING BUILDINGS—The dimensions of a building to house a corn drier depends upon the type of drier to be installed the amount of dried corn to be stored and the method of storing whether in silos, bins, sacks or loose, also what conveyors are to be installed. Storage is sometimes provided for wet corn awaiting to be dried. Convenience of manœuvring lorries delivering wet corn to the hopper feeding the drier must be especially considered. The wet grain hopper which must be under cover should be so placed that the tail of the lorry delivering the corn can shoot it into the hopper with the minimum amount of handling.

Provision for the furnace and fuel supplying heat to the drier depends upon the type of furnace and fuel but the furnace room should be entirely cut off from the drier building. Special consideration must also be paid to the construction of wet grain hoppers for as they are invariably below ground precautions must be taken to keep them watertight. Grain silos which can be emptied at will by blowing grain from one silo to another are becoming more popular. This system of storage requires higher buildings than when grain is stored in sacks or loose unless the building is of two or more floors.

Unless the whole floor of a grain store is raised a loading ramp 3 ft. to 3 ft. 6 in. high above the roadway is desirable.

Space required for grain—Wheat, 45 cubic feet per ton; Barley, 50 cubic feet per ton; Oats, 66 to 80 cubic feet per ton.

GRASS DRYING BUILDINGS—The size of these as in the case of Corn Drying Buildings depends upon the type of drier to be installed. Generally speaking a building of the Dutch barn type with a lean-to on either side fulfils all requirements. Convenience for the reception of wet grass under cover and storage of the finished product are main considerations. Particular attention must be paid to fire risks and with this object in view siting as far removed from other buildings as conveniently possible is desirable.

The space required for dried grass depends upon whether the grass is to be trussed or compressed into cubes, etc.

The three main types of drier are—

(i) Tray driers which dry unchopped grass,
(ii) Conveyor driers which dry unchopped grass on a continuous conveyor belt,
(iii) High temperature driers which dry chopped grass by means of a stream of hot gases.

Asbestos is better than galvanised corrugated iron for the walls and roofing of these buildings.

Space required for dried grass :—

Meal in bags :—6 to 7 cubic feet per cwt. or 130 cubic feet pe ton (average).

Grass in bales :—8 to 10 cubic feet per cwt. or 180 cubic fee per ton (average).

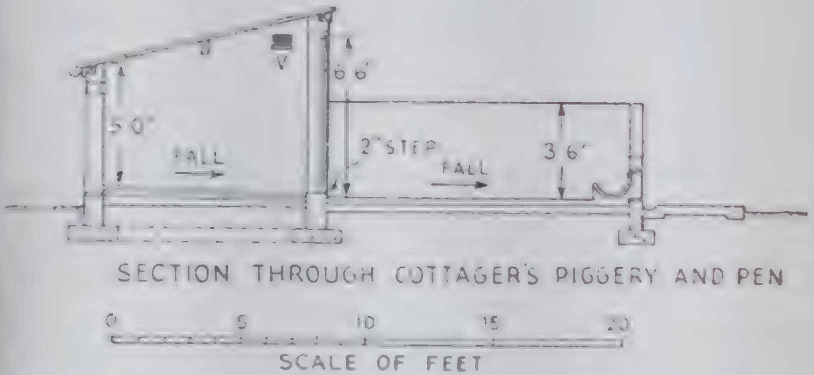
PIGGERIES.

Cottagers' Piggery—Sty, 8 ft. by 8 ft., Pen, 8 ft. by 12 ft Height 6 ft. on pen side falling to 4 ft. 6 in. minimum.

The floor of sty should be insulated and at least 8 in. abov surrounding ground level and with a fall towards the doorway A 2 in. step or sloping threshold should be provided down fro sty to pen.

Walls of pen at least 3 ft. 6 in. high.

Galvanised iron is unsuitable for the construction of the sties of piggeries but is useful in forming pens. The pen should be drained to an external catch pit.



SECTION THROUGH COTTAGER'S PIGGERY AND PEN

See diagrams 4, 5, 6.

Fig. 23

Scandinavian Type Piggery—Feeding passage 4 ft. wide in the clear. Pens 8 to 10 ft. deep. Dunging passages 3 ft. 6 in. wide. Height, floor to springing of roof 8 ft. minimum enables building to be put to other uses should occasion arise. Insulated bed 1½ in. above pen level with general fall towards opening to dunging passage. Dunging passage 1½ to 2 ins. below pen level with fall towards drainage opening in external wall. It is very undesirable for one pen to drain through another. Unless there is a natural fall in the ground outside open drainage channels running the length of the building to a gully become deep and are likely to be stopped up with litter. Gullies to each pair of pens and an underground glazed stoneware drain is preferable. Pen divisions not less than 3 ft. 6 in. high. Twelve-inch glazed stoneware or galvanised iron feeding troughs 12 in. to 18 in. of trough per pig, tubular rails giving access to feeding troughs generally preferable to swinging shutters or fixed screen. Food preparation room should permit of easy delivery of food and free access to feeding passage with room for boiler. This should be entirely cut off from the pig pens, and it is therefore sometimes convenient to have it of two storeys, the upper floor being used for the storage of meal.

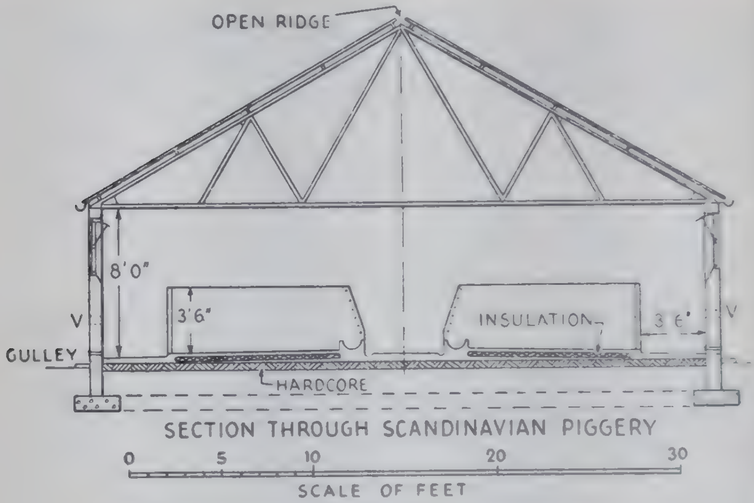

OPEN RIDGE
8'0"
3'6"
INSULATION
3'6"
V
V
GULLEY
HARDCORE
SECTION THROUGH SCANDINAVIAN PIGGERY
0
5
10
20
30
SCALE OF FEET

Fig. 24

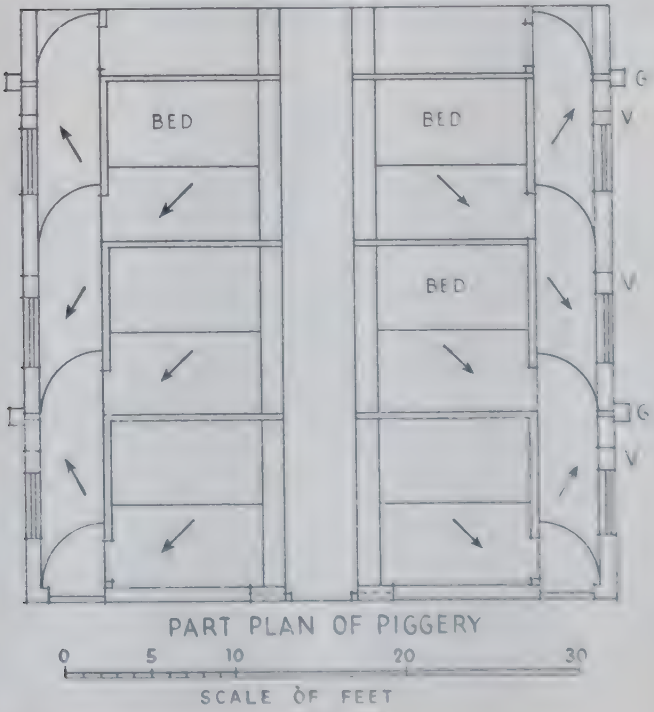

BED
BED
BED
G
V
V
G
V
PART PLAN OF PIGGERY
0
5
10
20
30
SCALE OF FEET

Fig. 25

Insulation and ventilation are very important. An open ridge 2 in. to 3 in. wide covered with fine mesh wire is generally satisfactory. Centre hung casements high in the gable ends of the building are also desirable. 18 in. by 9 in. fresh-air inlets into the dunging passages *not* opposite the openings into the pen are much favoured by some pig keepers. They can be of the hit-and-miss type for regulating the amount of air coming into the building.

The cubic capacity per head of pig should normally be approximately 200 cubic feet.

The roofs of piggeries should preferably be of two thicknesses of material for insulation purposes. Combined asbestos sheets fulfil this requirement.

Walls generally should be rendered smooth in cement and sand for a height of 3 ft. 6 in. Adequate light should be provided especially to the dunging passages. Standard hopper windows with a splayed internal sill are suitable. Roof lights at the rate of 50 square in. per pig should be so arranged that direct rays of the sun do not fall upon the pigs.

Farrowing crates are generally favoured but if farrowing rails are fitted they should be removable. They are usually placed 9 in. above the floor level and project 10 in. from the pen walls.

It is necessary to cover all timber accessible to the pigs, such as doors, with sheet metal to prevent gnawing.

SHEEP DIPS—These should consist of a collecting pen where the sheep are assembled before passing through the foot bath 3 in. to 6 in. deep on their way into the catching pen. The collecting pen should permit of an area of 3 ft. super per sheep assembled. From the catching pen a gate approximately 2 ft. 6 in. wide should lead direct to a dipping tank. This should be approximately 4 ft. deep and 5 ft. long, 2 ft. 3 in. at the top tapering to 18 in. at the bottom with a slope of one in two up to the draining pen. From the draining pen it is usual to provide a pen where the sheep can be held before releasing them to their pasture.

The draining pen should be provided with a gully to take the dipping solution back to the dipping tank. Provision must be made to prevent droppings being washed back into the tank.

A drain must be provided at the bottom of the dipping tank and foot bath to take expended solution to a suitable outfall which must be well away from any gathering grounds of water supplies.

It is usual to rib the floor of the foot bath and slope up from dipping tank to dripping pen to ensure that the solution gets between the hoofs of the animals. The fences around the various pens need to be not less than 4 ft. high and if of timber with the rails sufficiently near to each other and on the pen side to prevent injury to the animals.

All pen floors must be laid to falls to permit of easy drainage.

STABLES—Horses are frequently kept in open yards with shelters or allowed to run in paddocks all the year round especially in the Eastern Counties of England.

When a stable is provided it should be from 16 to 18 ft. deep with stall divisions 6 ft. 6 in. centre to centre.

Swinging bales are sometimes preferred to fixed stall divisions or where horses are used to working together and are docile divisions can be omitted.

The walls should be at least 9 in. thick and of good hard bricks where they are likely to be kicked. Heights floor to wall plate 8 ft. minimum, or where there is a loft over not less than 9 ft. from floor to ceiling.

A pitched roof is desirable with adequate ridge ventilation.

The floors which are subject to hard wear should be not less than 4 in. thick of good hard aggregate concrete roughened on a bed of hardcore.

The heel panel under the horses hind legs should be 6 in. thick and preferably of granite setts or Staffordshire blue bricks.

Only surface drainage should be provided within a stable to discharge on to an outside trapped gully. The stall floor should be given a fall of 1 in. from each side to the centre with a longitudinal gutter one foot beyond the heel post or 10 ft. from the manger-wall with the rear gangway falling towards this gutter.

Hopper windows should be used and give at least 6 ft. super of glass for each animal or 4 ft. super of roof lighting.

Minimum air space per animal 1,000 cubic feet. Baffled fresh air inlets under the manger are recommended with one 4 in. diameter pipe per horse as ridge outlet.

Doors should be 7 ft. high by 4 ft. wide in the clear divided with lower half 4 ft. high and upper half 3 ft. high. The top of lower half should be protected with metal to prevent gnawing where horses are housed in loose boxes.

Firm fixing is essential for stall division. They should be 8 ft. long and 6 ft. 6 in. high at manger end sloping to 5 ft. high at heel posts. Kicking panels 3 ft. by 4 ft. of hardwood with grain running horizontally are desirable. Heel post 6in. by 6 in. with boarding flush with post. Where there is a loft over a stable it is sometimes convenient to allow the heel posts to extend to the underside of a floor beam to reduce the span of the loft floor joists.

Mangers and hay racks should be 3 ft. 3 in. to 3 ft. 6 in. from floor to top of curb, one half of length being devoted to manger proper the other half to the hay rack. Hay racks above mangers are not recommended. Width of manger 1 ft. 6 in, depth 12 in. (Tying rings should be fixed to front curb or chin rail.) If mangers are of timber a strip of metal fixed to the front curb will stop gnawing.

TABLE 154

SUITABLE DIMENSIONS FOR SOME FARM BUILDINGS

	Length	Breadth	Height	Area
Dutch Barns ..	In 15 ft. bays	20 ft. to 45 ft.	16 ft. to 22 ft.	
Cattle yards per animal—				
Horned ...	10 ft.	15 ft.	8 ft. to 12 ft.	150 ft. super
Dehorned ..	10 ft.	10 ft.	8 ft. to 12 ft.	100 ft. super
Implement Sheds	10 ft. 6 in. to 15 ft. bays	15 ft. to 45 ft.	8 ft. to 16 ft.	
Workshops—	Usually one complete bay of implement shed for its full depth.			
Stables ...	6 ft. 6 in. per stall	18 ft. to 20 ft.	8 ft. to plate where pitched roof 9 ft. to ceiling where loft over	
Loose boxes ...	12 ft. min.	10 ft. min.	8 ft. to wall plate	120 ft. super
Isolation boxes	15 ft.	12 ft.	8 ft. to wall plate	180 ft. super
Cowhouses—				
Single range	3 ft. 6 in. to 4 ft. per cow according to breed	14 ft. 6 in. without feeding passage	8 ft. to wall plate	
Double range	Ditto feeding passages	27 ft. ditto 3 ft. wide	8 ft. to wall plate	

	Length	Breadth	Height	Area
Piggeries (Cottagers)— Sty ...	8 ft.	8 ft.	6 ft. to 7 ft.	64 ft. super min.
Pen ...	12 ft.	8 ft.		
Piggeries— Scandinavian	10 ft. 6 in. bays	32 ft.	8 ft. to plate	
Bull-boxes ...	15 ft.	12 ft.	8 ft. to plate	180 ft. super
Pen	20 ft.	12 ft.		240 ft. super

BUILDING MATERIALS—GENERAL DATA

Foundation pressures—

Description of Ground.	Maximum load in tons per square ft.
Silt, peat, alluvial deposits, made ground thoroughly settled, very wet sand ...	$\frac{1}{4}$ to $\frac{1}{2}$
Loose sand, soft clay	$\frac{1}{2}$ to 1
Confined sand, natural clay, sandy clay	2
Firm dry sand	3
Natural bed of compact gravel, chalk, stiff clay well below ground level ...	4
Hard sandstone, limestone solid, hard chalk	5 to 10
Igneous rocks	15 up

Increase in Bulk Excavation—

Sand and gravel	$\frac{1}{10}$ to $\frac{1}{8}$
Earth, loam, clay	$\frac{1}{5}$ to $\frac{1}{4}$
Chalk	$\frac{1}{3}$
Rock	$\frac{1}{2}$

Weight and Bulk before Excavation (approx.)—

Ground	Weight in tons	Cubic feet
Clay	1	20
Sand and gravel ...	1	22
Chalk	1	18
Earth	1	24

CONCRETE

Concrete—Composed of matrix or cementing material and aggregate consisting of gravel, ballast, broken stone or brick, and sand.

Concrete mixes for various purposes

	Cement	Sand	Aggregate
Mass concrete in foundations, roads, etc.	1	3 or leaner	6 to pass 2 in. ring.
First quality concrete in foundations, etc.	1	2½	4–5
In floors	1	2	4–6 to pass 1½ in. ring.
Walls *in situ*	1	2	4
Reinforced concrete work ...	1	2	4
Special reinforced concrete work and waterproof concrete	1	1½	3 to pass ¾ in. ring

Sand must be clean and sharp and the aggregate free from loam, vegetable matter or other impurities.

Materials per cubic yard of Concrete

Proportions	Portland Cement in lb.	Sand cubic feet	Aggregate cubic feet
1–3–6	380	13	25·5
1–2–6	450	9	27
1–2–4	550	12	24

Foundations—The depth and thickness of concrete foundations is determined by the nature of the subsoil. They should as a general rule be not less than 9 in. in thickness and extend at least 6 in. on either side of the wall which they support. In a clay subsoil extra depth and reinforcement is desirable. On fens and other soft subsoils reinforced concrete rafts extending well beyond the limits of the buildings are necessary. Brick reinforcement around the building at intervals usually immediately below the window sill level and below the wall plate is also desirable. Farm buildings in mining areas need similar precautions.

Other uses for reinforced concrete—Reinforced concrete is now extensively used for posts, piers, roof trusses, wells, culverts, drinking troughs, fencing posts, etc. They must be carefully made and vibrated to give a dense concrete with proper cover to the reinforcement otherwise the steel will rust and cause the concrete to split. Bollards or spurs are necessary at the feet of all free standing piers to prevent fracture by wheeled implements.

Concrete pavings and roads—The thickness of concrete roads and pavings depends upon the traffic carried. For cattle yards paths and causeways 4 in. of concrete on a suitable bed of hardcore is generally sufficient.

Roads should be at least 6 in. thick either with or without reinforcement and suitably cambered and finished with the edges slightly above the general ground level. A width of 9 ft. is generally sufficient if passing places are provided. It is generally convenient to form these at gateways.

Passing places should be at least 15 ft. wide and 40 ft. in length.

Expansion joints are necessary every 20 ft. in the run of the road. They should not be less than ¾ in. wide and be filled with bituminous compound. Yards should be laid in panels not exceeding 300 to 400 ft. super in area.

The concrete should be finished with a reasonably rough surface to provide a good foothold for livestock. This can be produced by tamping the concrete at right angles to its length with a straightedge.

Appropriate provision should be made for the disposal of surface water as circumstances dictate.

Concrete wheel tracks 3 ft. wide and 3 ft. apart are sometimes used as a means of economy. The space between the tracks is used as the walking space for horses pulling the vehicle with wheels on the concrete tracks.

Passing spaces over concrete roads for crawlers, etc. can best be formed with sleepers laid slightly above the surface of the road.

Stabilised earth roads are not generally suitable for use in this country.

DRAINS

Drains—Stoneware pipes are made in the following diameters :—3 in. to 15 in., 18 in., 21 in., 24 in., 27 in., 30 in. and 36in.

Concrete pipes, 9 in. rising by 3 in. to 48in., 54 in. and 60 in.

Cast iron pipes, 3 in. to 16 in. then rising by 2 in. to 26 in., 27 in., 28 in., 30 in., 32 in., 33 in., 36 in., 38 in., 40 in and 42 in.

TABLE 155

Concrete in drain beds. Cubic yards per yard run.

4 in. bed	Diameter of pipe			
	4 in.	6 in.	9 in.	12in.
Haunched ...	·10	·12	·15	·19
Encased ...	·16	·17	·25	·32

Drain sizes and falls.

Drains should not be larger than necessary and should have a velocity of 4 ft. per second when flowing full. Satisfactory falls and velocities are given in the following table. Velocity decreases when the drain is less than half full.

TABLE 156

Stoneware pipes, Discharge and Velocity

Diameter of Drain	Area in Square inches	Fall	Velocity in ft. per second	Discharge Gall. per minute half-full
4 in.	12·56	1 : 40	4·56	75
6 in.	28·27	1 : 60	4·56	168
9 in.	62·60	1 : 90	4·56	377
12 in.	113·00	1 : 120	4·56	670

4 in. to 6in. drains usually fulfil all requirements on the farm. Manholes should be placed at not more than 100 ft. apart and where subject to traffic should have suitable heavy type covers.

Drains under traffic routes should be well below ground level and be surrounded in concrete. Drains passing under buildings should also be surrounded with concrete.

Trapped gullies generally should be used and for yards the street type gully with silt bucket is desirable.

Agricultural Land Drain pipes

1,000—2 in.	in 12 in. or 15 in. lengths weigh	17 to	19 cwt.
2½ in.	in 12 in. or 15 in. lengths weigh	24 to	26 cwt.
3 in.	in 12 in. or 15 in. lengths weigh	34 to	36 cwt.
4 in.	in 12 in. or 15 in. lengths weigh	45 to	47 cwt.
6 in.	in 12 in. or 15 in. lengths weigh	100 to	102 cwt.

Number per acre

12 ft. apart 3,630 of 12 in. pipes
15 ft. apart 2,905 of 12 in. pipes
18 ft. apart 2,420 of 12 in. pipes
20 ft. apart 2,074 of 12 in. pipes
24 ft. apart 1,815 of 12 in. pipes
27 ft. apart 1,613 of 12 in. pipes
30 ft. apart 1,452 of 12 in. pipes

PAVING

TABLE 157

Paving stones

Pavings	Area covered by one ton in square feet	
	Thickness	Area
York paving ...	2 in.	86
York paving ...	2½ in.	70
York paving ...	3 in.	56
Granite	3 in.	55
Granite	4 in.	40
Granite	5 in.	32
Granite	6 in.	27

TABLE 158

Tar Macadam

Consolidated thickness	Bottoming	Yards super per ton	Topping	Yards super per ton
2 in.	1½ in.	18	½ in.	40
2½ in.	2 in.	14	½ in.	40
3 in.	2½ in.	11	½ in.	40

Concrete paving

Thickness	Yards super covered by one cubic yard of concrete
4 in.	9
6 in.	6

BRICKS

Bricks	Average Size	Weight per 1,000 (tons)
Flettons ...	8¾ in. × 4 3/16 in. × 2⅝ in.	2½
Stocks ...	8¾ in. × 4 3/16 in. × 2⅝ in.	2¼ to 3⅛
Facings ...	8¾ in. × 4 3/16 in. × 2⅝ in.	2¾ to 3½
Engineering ...	8⅞ in. × 4¼ in. × 3 in.	3⅞ to 4⅛

One rod of brickwork—272 ft. super 1½ brick thick
One rod of brickwork—408 ft. super 1 brick thick
One rod of brickwork—306 feet cubic.
One rod of brickwork—requires from 4,350 to 4,000 bricks in mortar
One rod of brickwork—requires approximately 2 cubic yards of mortar with a ¼ in. joint or 3 cubic yards of mortar with ⅜ in. joints.
One foot super of facing bricks requires 6 facing bricks.
One cubic foot of brickwork requires 15 bricks.
One cubic yard of brickwork requires 390 bricks.
One yard super of walling.—1½ brick thick. 144 bricks.
One yard super of walling.—1 brick thick. 96 bricks.
One yard super of walling.—½ brick thick. 48 bricks.
One cubic foot of brickwork weighs approximately 112 lbs.

Average safe load in tons per square foot

Ordinary brick in lime mortar	2–4
Ordinary brick in cement mortar	5
Hard brick in cement mortar	8
Blue brick in cement mortar	12
Portland cement concrete (1–2–6)	12

No disengaged brick pier should have a height of more than 6 times its base width without lateral supports. With adequate lateral support not more than twelve times base width which should not be less than 13½ in.

Mortar—

Lime—1 bushel of Lias lime = 75 lb.
One cubic foot of lime = 45 lb. average.
Blue Lias lime per cubic ft. = 55 lb.
Hydrated lime per cubic ft. = 35 lb.
3 bushels of lime = 1 bag.

One cubic yard of lime equals 21 striked bushels or 17 heaped bushels.

Portland Cement—
1 bushel of Portland cement = 112 lb.
2 bushels of Portland cement = 1 bag.
1 bag of Portland cement = 2½ cubic feet = 2 cwt.
10 bags of Portland cement = 1 ton.
1 paper bag of Portland cement = 1 cwt.
1 cubic foot of Portland cement = 90 lb.

TABLE 159

Materials for mortar by volume.

Kind of mortar	Cement	Lime	Sand
Lime mortar	—	1	2 to 3
Cement lime mortar ...	1	3	10 to 12
Cement mortar	1	—	2 to 6

When mixed with water lime and sand decrease in volume ¼ cement and sand ⅙ and aggregate cement and sand in concrete, about ¼.

Hollow Walls—Cavity walls are frequently constructed in exposed positions to keep the interior of a building dry. The usual thickness of walls is 11 in. for small domestic work such as farm workers' cottages and small farm houses of two storeys with thicker interior skins to the walls for larger structures.

The walls consist of two 4½ in. walls built with a 2 in. space between them tied together with galvanised iron ties. At least two ties should be used to each yard super of walling spaced 2 ft. 6 in. to 3 ft. apart horizontally and every fourth or sixth course vertically built in chequerwise with extra ties at the openings, angles, and piers of buildings.

Damp-proof Courses—All walls should be provided with a damp-proof course laid not less than 6 in. above the finished ground level. A damp-proof course should be provided in all chimney stacks and parapet walls as circumstances dictate. Two courses of hard slates laid breaking joint in cement mortar 1–1 are considered satisfactory. Other forms of damp-proof courses are —

¾ in. asphalt which must be laid by specialists,
Two courses of blue bricks in cement mortar.
Purpose made stoneware damp-proof blocks.
Bituminous felt in various forms, the most satisfactory of which is the type having a lead foil sandwich.
Strip copper.

TIMBER

Measurements of timber—

Standard = 165 cubic feet = St. Petersburg standard = 120 pieces 11 × 1½ × 12 ft.

One square = 100 ft. superficial any thickness.

One ton Shipping = 42 cubic feet.

Logs = Trunks, bark and branches removed.

Balks = Square logs at least 12 in. wide.

Whole = 12 in. × 12 in. (half timbers 12 × 6 in.).

Plank, 11 wide or more, 2 to 6 in. thick (average 3 in.).
Battens, 4 to 7 in. wide by 2 to 4½ in.
Boards, less than 2 in. thick, used for flooring.
Quartering Square section, 2 to 6 in. side.
Forty cubic ft. rough or 50 cubic ft. squared = 1 load.

Forms of Roofs for various Spans—
Couple up to 11 ft. Couple close to 14 ft. Collar to 17 ft.
King post to 30 ft. Queen post to 45 ft.

TABLE 160

Scantlings for Timber Roofs.

Span in feet	Tie Beam	Principal Rafter	Common Rafter	King Post	Struts
20	8 × 3	4 × 3	3 × 2	3 × 3	3 × 3
22	8 × 4	4 × 4	3½ × 2	4 × 3	4 × 3
26	9 × 4	4½ × 4	4 × 2	4 × 4	4 × 4
30	11 × 4	6 × 4	4½ × 2	6 × 4	4½ × 4
34	9 × 4	4½ × 4	3 × 2		4 × 4
38	9 × 4	5 × 4	4 × 2		4½ × 4
42	11 × 4	6 × 4	4½ × 2		5 × 4
46	11 × 5	6 × 5	5 × 2		5 × 5

Span in feet	Purlins	Queen Post	Straining Beam	Straining Sill
20	7 × 3			
22	7 × 4			
26	7 × 4			
30	8 × 4			
34	7 × 4	4 × 4	7 × 4	4 × 2
38	7 × 4	4½ × 4	8 × 4	4 × 3
42	8 × 4	5 × 4	8 × 4	4 × 3
46	8 × 4	6 × 5	9 × 5	5 × 3

TABLE 161

Scantlings for Collar Beam Roofs

Span in feet	Collar	Rafters	Ridge
8	3 × 2	3 × 2	7 × 1¼
12	4 × 2	4 × 2	7 × 1¼
16	5 × 2	5 × 2	8 × 1½
20	6 × 2	6 × 2	9 × 1½

Conversion of running lengths into cubic ft. or standards.

Sectional area in Square inches	Cubic feet per foot run
½	·00347
1	·00694
2	·01389
3	·02083
4	·02778
5	·03472
6	·04166
7	·04860
8	·05556
9	·06250
10	·06944

Cubic feet by ·00606 = standards.

Superficial Area per Standard—

Thickness in.	Square yards	Square feet	Squares
½	440	3960	39·6
¾	293·33	2640	26·4
1	220	1980	19·8
1½	146·66	1320	13·2
2	110	990	9·9
2½	88	792	7·92
3	77·33	660	6·6

Timber required per square of flooring.

Square edge.

Width in.	feet run ft.	feet super ft.
3	418	105
5	247	103
6	205	103
7	175	102

ADD 5 per cent. cutting and waste

Cubic feet of timber per square—

TABLE 162

	Centres			
Joists, Rafters, etc.	12 in.	14 in.	16 in.	18 in.
9 × 2	12·5	10·7	9·4	8·3
7 × 2	9·7	8·4	7·3	6·5
5 × 2	6·9	6·0	5·2	4·6
4 × 2	5·6	4·8	4·2	3·7
3 × 2	4·2	3·6	3·1	2·8

TABLE 163

Insulation and Building Boards	Thickness	Standard sizes	Weight per square foot
		Width—Length	
	$\frac{5}{16}$ to $\frac{1}{2}$ in.	4 ft. × 6 ft. to 14 ft.	·5 to ·7 lb.
Medium hardboard	... 4 to 12 mm	5 ft. × 8 ft.	·6 to 1 lb.
Hardboard ...	... $\frac{1}{8}$—$\frac{3}{16}$ in.	5 ft. × 8 ft.	·6 to ·8 lb.

Strength of rectangular timber beams.

W — Load in cwt.
b — breadth in inches
d — depth in inches
L — clear space in feet
C — constant

Constant—c	
Ash	6
Pitch pine, teak, oak ...	5
Red deal, Northern pine ...	4
Spruce. Yellow pine elm ... Columbian pine—	3

Breaking weights centrally loaded $= W = \dfrac{b \times d^2 \times c}{L}$

Safe load in centre $= W = \dfrac{b \times d^2 \times c}{L \times 5}$

Safe distributed load $= W = \dfrac{b \times d^2 \times c}{L \times 2{\cdot}5}$

Roof Coverings.

Slates—Gauge = Distance centre to centre of nail holes
Margin = The portion of slate exposed to the weather
Head = Upper end
Tail = Lower end

The gauge of slates is determined by the following formulæ —

A—For head nailed slates the gauge—

$$= \frac{\text{length of slate—1 in.—lap}}{2}$$

B—For centre nailed slates and tiles the gauge—

$$= \frac{\text{length of slate} - \text{lap}}{2}$$

To find the number of slates required to cover one square 100 ft. super, one square in inches is divided by width of slate in inches by gauge in inches.

Slates are sold by the "thousand" or mil of 1,200, except Westmorland Slates, "Imperials," "Rags," and "Queens," which are sold by the ton.

For pitches of 45° and over, a 2½ in. lap is sufficient. For pitches under 45° a lap of 3 in. is necessary. If the pitch is less than 30°, the slates should not be less than 12 in. wide.

The sizes in general use together with the gauge, allowing for a 3 in. lap, for centre nailed slates, the number of squares that a mil will cover, allowing 5 per cent. for waste, the number of slates required to cover one square (100 sq. ft.), and the size of nails, are shown in the following table :—

TABLE 164

Type	Size in inches	Gauge for 3 in. lap centre nailed	No. of squares covered by 1,200	No. of slates to cover 100 sq. ft.	Size of nails
Doubles	12 × 8	4½	2·8	430	1½
„	12 × 6	5	2·5	480	1½
Ladies	14 × 12	5½	5	240	1½
„	14 × 8	6½	4	300	1½
Viscountess ...	18 × 10	7½	6	200	1½
Countess ...	20 × 10	8½	7	171	1½
Marchioness ...	22 × 12	9½	9·2	130	1¾
Duchess	24 × 12	10½	10	125	1¾

Battens—The size of battens is usually 1 in. to 2 in. by 1 in. but the thickness may be reduced when battening on boarding.

Feet run of slating battens per square.

TABLE 165

Length of slate	Centre nailed. Lap. 2½ in.	3 in.	3½ in.	4 in.
12	250	268	280	300
13	230	240	250	268
14	210	220	230	240
16	180	186	190	200
18	155	160	166	170
20	140	146	150	154
22	124	130	135	138
24	112	115	120	124

Nails and Nailing—Slates are often holed for nailing 1 in. t 1½ in. from the head, they are better centre holed. The onl advantage gained by head nailing is the extra cover to the nails but this is not important. The best nails to use are copper, a they are less liable to corrosion. Composition nails, compose of an alloy of zinc, tin and copper, are tougher and less likely t bend than copper, zinc nails are not durable, and their heads ar liable to come off. Each slate should be nailed with two nails.

	Number per pound 1¼ in.	1½ in.	2 in.
Composition	164	144	96
Copper	190	145	90
Zinc	280	220	90

Asbestos slates are made in the following sizes 24 in. by 12 in., 20 in. by 10 in., 18 in. by 8 in. and 12 in. by 6 in.

Tiling—Plain tiles. Approximately 10½ in. by 6½ in. by ½ in. thick are made of clay or concrete. 550 plain tiles laid to a 4 in. gauge will cover one square (100 ft. super).

Weight per square 12 cwt. (average). Minimum pitch 40°. Average weight per thousand 23 cwt. Battens required per square of tiling : 3½ in. gauge, 345 ft. run ; 4 in. gauge, 300 ft. run.

Bonnet hips for use with plain tiles are the most satisfactory. Ridge tiles are usually made in 12 in. lengths. The usual sizes for battens are 1½ in. by ¾ in. for plain tiles and 2 in. by 1 in. for pantiles.

Absorption—Machine-made tiles should not absorb more than 10 to 12 per cent. of their weight after immersion in water for 24 hours. Hand-made sand-faced tiles may absorb as much as 16·5 per cent.

Pantiles are curved in form and measure 14 in. by 9 in.

They are laid with a lap of 3 in. to 4 in. that is one tile overlaps the one beneath by this amount. They should be laid by experienced workmen according to local custom.

Patent tiles of various forms are on the market and must be laid in accordance with the maker's instructions.

Interlocking tiles are approximately 15 in. by 9 in. and require 170 tiles per square. Their weight is about 7 cwt. per square and they must be laid at not less than 35° pitch. The usual batten gauge is 11 in.

TABLE 166

Type	No. per square	1,000 tiles will cover (yd)	Weight per square (cwt.)	Weight per 1000		Batten gauge approx. (in.)	Size of tile (in.)	Approx. battening per square in ft. run
				tons	cwt.			
Plain Tiles (Brosely machine-made) ...	550	20	11	1	1	4	10½ × 6½	300
Plain Tiles (Reading hand-made), lap 2½ in. ...	550	20	13	1	4	4	10½ × 6½	300
Pan Tiles (sand-faced)	170	66	7	2	0	10½	13½ × 9½	130
Double Roman	85	132	7	3	10	13½	16½ × 14	100

Cedar Shingles—Length, 18 in. ; Width from 4 in. to 12 in. ; Weight 144 lb., per square when laid at 5 in. gauge. Gauge 5 in. for all pitches down to 30°. Battens 2 in. by 1 in. One bundle of shingles will cover 28 square ft. with a 5 in. lap. Four bundles will cover one square with a 5 in. gauge and 6 in. lap.

Asbestos Cement Roofing—

1.—Big six or Super six corrugated sheets.
2.—Standard corrugated sheets.
3.—Trafford or Watford tiles.

TABLE 167

	1	2	3
Standard lengths 3 ft. by 6 in. up to 10 feet.	Ft. in.	Ft. in.	Ft. in.
Width approx. laid	3 3	2 1	3 8
Pitch of corrugations	0 6	0 3	1 1½
Depth of corrugations	0 2	0 1	0 2
Purlin spacing	4 6	3 0	4 6
End lap	0 6	0 6	0 6
Side lap	0 4	0 2	0 4
Weight of 100 square feet laid approx.	311 lb.	304 lb.	308 lb.
Weight per square yard of sheeting	12½ lb.	13¾ lb.	13 lb.

Asbestos cement sheets can also be supplied for curved roofs

The Univent corrugated asbestos cement slotted sheets ar eminently suitable for use over covered yards. They have all th advantages of the Yorkshire boarded roof with none of th disadvantages.

Yorkshire boarded roofs for stock yards consist of 6 in. b 1 in. boarding spaced ¼ in. to ½ in. apart channelled or groove on the top near each edge and rebated on the underside. Th boards which run down the roof are fixed to timber purlins wit one 4 in. galvanised nail in the centre of the boards. Two c three galvanised hob nails driven in to the top of each purli prevents condensation moisture collecting between the boar and the purlins and setting up rot. The boarding must b particularly well seasoned and creosoted under pressure.

Semi-permanent Buildings of Asbestos—Semi-permane buildings are obtainable made up of asbestos components various forms.

Some of the better known types are the asbestos semi-circul Nissen and the Watford handcraft hut both of which should b erected on a plinth of brick or concrete in accordance with the makers' instructions.

Galvanised corrugated sheets are of two standard widths one with eight and the other with ten corrugations.

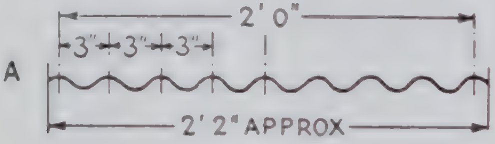


Fig. 26

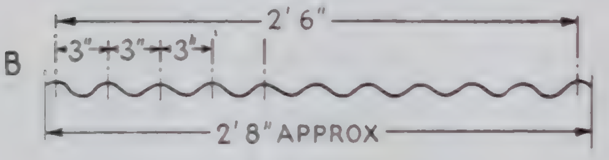


Fig. 27

TABLE 168

Approximate weight per sheet No. 8 corrugations 2 ft. 2 in. wide.

Length	Gauge				
	18	20	22	24	26
	lb.	lb.	lb.	lb.	lb.
5 ft.	26	19½	16	13½	10
6 ft.	31	23½	19½	16	12
7 ft.	36	27½	22½	18½	14
8 ft.	41½	31½	26	22½	16
9 ft.	46½	35	29	24	18
10 ft.	52	39	32½	26½	20

TABLE 169

Average weights of sheets required to cover 100 square feet including laps

18 gauge	20g	22g	24g	26g
2 cwt. 2 qr.	1 cwt. 3 qr. 24 lb.	1 cwt. 2 qr. 7 lb.	1 cwt. 1 qr. 6 lb.	3 qr. 23lb.

Approximate weight per sheet No. 10 corrugations 2 ft. 8 in. wide

TABLE 170

Length	Gauge				
	18	20	22	24	26
	lb.	lb.	lb.	lb.	lb.
5 ft.	30·5	23·5	19·5	16	12
6 ft.	36	28·5	23	19	14·5
7 ft.	42·5	33	27·5	22·5	17
8 ft.	48·5	38	31	25·5	19·5
9 ft.	54·5	42	35	28·5	21·5
10 ft.	60·5	47·5	38·5	32	24

TABLE 171

Average area covered by one ton including laps in feet super

Gauge...	18	20	22	24	26
Area ...	800	1,020	1,280	1,530	2,100

Purpose made galvanised ridge capping of various designs can be obtained usually in 6 ft. lengths.

Corrugated roof lights made to suit the above roofing sheets and of various sizes either as dead lights or skylights to open are also made.

Corrugated curved sheets are made to suit roofs of various spans.

Sheets are fixed to steel framing or roof purlins with hook bolts and bent washers or to timber with galvanised cone headed nails or drive screws with washers.

Sheets are fixed to each other with galvanised rivets and washers or bolts and nuts.

The holes for screws or bolts should always be made at the top of the corrugation.

An end lap of 6 in. and a side lap of at least one corrugation should be adopted.

Valleys are formed of plain sheets of galvanised iron and valley and wall gutters of galvanised sheet steel or cast iron to suit individual requirements. If of sheet iron they should be of heavy gauge.

Purlins should be spaced according to the gauge of the sheets. Curved sheets are self supporting over spans of 12 to 15 ft. provided they are well secured to strong wall plates.

Protected metal corrugated sheets are very durable but are more expensive than other forms of roofing sheets. They are particularly suitable for covering the roofs or walls of all farm buildings. They consist of corrugated metal sheets entirely enclosed in a bituminous compound which gives the sheets an unlimited life. They are made in various colours and textures but the natural black sheets are the most durable and cheapest.

Sheets are made of various lengths from one foot rising by 6 in. to ten feet. Sheets are 2 ft. 3 in. wide overall, having nine 3 in. corrugations, and covering 2 ft. as laid with a single corrugation side lap.

Purlins can be spaced 5 ft. 6 in. to 7 feet apart. In fixing or cutting the sheets it is essential that all exposed metal is sealed with the special compound supplied with the sheets for the purpose. The use of protected metal is recommended for although it is more expensive as previously stated the life is unlimited.

Corrugated aluminium sheets similar to corrugated sheets are fast coming into favour but are more expensive than corrugated iron. They are light, durable and require no maintenance.

Perspex—Transparent corrugated "Perspex" for roof lighting is shaped to match almost all standard corrugated metal and asbestos roofing sheets. The sheets are easy to install using ordinary hook bolts or nails and washers. The sheets can be obtained in lengths from 3 ft. rising by 6 in. to 7 ft. and of a width to match the roofing sheets with which they are to be used.

All holes in the sheets must be drilled. Sheets can be cut with any fine tooth saw such as a hack saw.

The sheets weigh approximately 0·9 lb. per square foot and are normally ⅛ in. in thickness.

Purlin spacings are as follows—

Pitch of Corrugations.	Purlin spacing.
2⅞ in. Protected Metal	5 ft. 6 in.
2⅞ in. (3 in. nominal asbestos)	3 ft. 0 in.
3 in. (corrugated iron)	3 ft. 0 in.
5¾ in. "Big six" and "Super six"	4 ft. 6 in.
13⅓ in. Trafford Tile	4 ft. 6 in.

PLASTER

Covering Capacity for screeding—

Proportions and Quantities	Thickness ½ in.	 ¾ in.	 1 in.	
1 bushel of neat Portland cement	2·8	2·1	1·4	square yards
1 bushel of cement and one bushel of sand	4·6	5·0	3·4	square yards
Do. and 2 bushels of sand ...	6·7	5·0	3·4	square yards
Do. with 3 bushels of sand ...	9·0	6·7	4·5	square yards

One bundle of laths contains from 360 ft. to 500 ft. run. A

bundle of laths and 500 nails will cover 5 yards superficial.
Single laths ⅛ in. to 3/16 in. thick ⎫ and vary from 2 to 5 ft. long
Lath and Half are ¼ in. thick ⎭ usual lengths 3 or 4 ft.

Coarse stuff—One part of lime to three parts of sand and one pound of hair for every three cubic feet of mortar.

Setting stuff—One part of lime to two parts of washed sand.

Plaster boards are now extensively used and are made in standard sizes of 36 in. by 28 in., 36 in. by 30 in. and 36 in. by 32 in. and ⅜ in. in thickness.

Larger boards from 6 ft. to 12 ft. in length and 2 ft. to 4 ft. in width and ¼ in. to ½ in. in thickness are also obtainable.

PAINT AND PAPER

Limewhiting—One bushel of lime, 10 gallons of water, and ¾lb. tallow, will cover 100 yards super, one coat. 1¾ bushels of lime, 17 gallons of water, and 1¼ lb. tallow will cover 100 yards super, two coat.

Water paints and Distempers—

	Surface	Coats 1st lb.	 2nd lb.
	Plaster ...	15	8
	Stucco ...	25	15
Whitening	Plaster ...	12	8

Paints—

	lb.
One gallon of ready mixed paint weighs	26–28
One gallon of Linseed Oil	8¾
One gallon of Boiled Oil	9
One gallon of Turpentine	8¼

Paints and enamels cover 80 to 100 square yards per gallon.

TABLE 172

Material	Quantity required to cover 100 square yards
	lb.
Priming	25 approx.
Paint, 1st coat	22 approx.
Paint, 2nd coat	18 approx.
	gal.
Enamel	1⅜
Enamel, 2nd coat	1¼
Stain (wood)	¾
Tar (Stockholm applied hot) ...	12
Creosote Wood (rough) ...	5
Creosote Wood (wrot) ...	2¼

One pound of putty for stopping will be required for every 10 yards of new painting.

Paper hanging—A piece of English wall paper is nominally 12 yards long by 21 in. wide and contains 63 square feet or 7 square yards.

Lining papers are 22½ in. wide by 12 yards long.

French wall papers, 18 in. wide and 9 yards long.

TABLE 173

Estimating paper required for ceilings—

	Measurement round room in feet						
	28	40	48	58	68	78	88
Pieces required ...	1	2	3	4	6	7	9

Paper required for walls—For finding the number of pieces of wall paper English Size, required for any room measure round the four walls in feet, including doors, windows, etc.

TABLE 174

Height in feet, skirting to cornice or ceiling	Length of four walls in feet															
	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88
7 and under 7½ ...	4	4	5	5	6	6	7	7	8	8	9	9	9	10	10	11
7½ ,, 8 ...	4	4	5	5	6	6	7	8	8	9	9	10	10	11	11	12
8 ,, 8½ ...	4	5	5	6	6	7	7	8	8	9	9	10	10	11	12	12
8½ ,, 9 ...	4	5	5	6	7	7	8	8	9	9	10	11	11	12	12	13
9 ,, 9½ ...	4	5	6	6	7	7	8	9	9	10	10	11	12	12	13	13
9½ ,, 10 ...	5	5	6	7	7	8	9	9	10	10	11	12	12	13	14	14

GLASS

Plate glass is sold by finish and thickness, ⅛ in. to 2 in. thick. Rough plate glass is the cheapest quality and is unrolled. It can be obtained reinforced with embedded wire netting. Reinforced glass resists shock and fire.

Flat drawn and sheet glass is

made in	15 oz.	21 oz.	26 oz.	32 oz.
Thickness in	3/16 in.	3/16 in.	⅛ in.	⅛ in.

PLUMBING

TABLE 175

Standard sizes of open top cisterns in inches.

Capacity in gallons (nominal)	Length	Width	Height
	in.	in.	in.
30	24	18	19
40	27	20	20
50	29	22	22
75	36	24	24
100	38	27	27
100	36	30	26
250	60	36	32
350	60	45	36
500	72	48	40
600	72	48	48
1,000	96	60	48

TABLE 176

Standard sizes of Hot Water Cylinders and Tanks.

Capacity (nominal)	Cylinders (in inches)		Tanks
	Diameter	Height	L. W. D.
20	14	36	24 × 16 × 15
25	16	36	24 × 24 × 12
30	18	36	24 × 24 × 15
30	—	—	24 × 18 × 19
35	18	36	30 × 18 × 18
40	18	42	27 × 20 × 20
50	—	—	29 × 22 × 22
60	21	48	30 × 23 × 24
70	—	—	36 × 24 × 23
75	24	48	— — —
100	24	63	— — —

Service pipes to fittings—

Diameter of pipes estimated on the head of water.

Height of cistern above outlet	Sizes of pipes to Baths	Sinks and lavatory basins, coolers, etc.
Up to 12 ft.	1 in.	¾ in. to ½ in.
Over 12 ft.	1 in. to ¾ in.	½ in.

Waste Pipes

The sizes of waste pipes and traps to various fittings.

TABLE 177

Fitting	Waste pipe and Trap
Baths	1½ in to 2 in.
Sinks	1½ in. to 2 in.
Lavatory Basins	1 in. to 1¼ in.
W.C.'s	3½ in. to 4 in.

Drinking Troughs—Cattle drinking troughs are made of galvanised wrot iron from three feet to 10 feet in length, 18 and 24 in. wide, and 13, 16, 20 and 24 in. deep. They can be supplied with a ball cock compartment either at an end or in the centre of the larger troughs. They should be securely fixed to prevent them being shifted by cattle.

Reinforced concrete troughs of various sizes are also made and are now extensively used.

Circular drinking troughs are particularly satisfactory in use.

All drinking troughs should be surrounded with a concrete platform or with hardcore as the nature of the soil dictates.

Rainwater pipes and eaves gutters—Rainwater pipes should have an internal area of not less than one square inch for every 80 to 100 square feet of roof surface measured on plan. The distance apart of rainwater pipes is regulated by the capacity of the eaves gutters. For domestic and farm building work generally the down pipes should not be further apart than 40 ft.

Rainwater Pipes

Diameter in inches	Area in Square inches
2	3·14
2½	4·90
3	7·07
4	12·57

Eaves gutters (Half-round)

Diameter of gutter ...	3 in.	4 in.	5 in.	6 in.
Sectional area of gutter in sq. in.	3·5	6·25	10	14

Ogee eaves gutter sizes, 4 in. by 2½ in., 4½ in. by 3 in., 5 in. by 3 in., 6 in. by 4 in., 8 in. by 6 in.

Heavy pattern galvanised iron gutter brackets are desirable and should be spaced at not more than three feet intervals.

TABLE 178

Daily yield of water from roof of 100 *square feet with varying rainfall.*

Rainfall	Loss. Evaporation, etc.	Requisite capacity of tank	Mean daily yield	Mean wettest year	Mean driest year
in.	per cent.	cubic feet.	gallons	gallons	gallons
20	25	50	2·0	3·3	1·5
25	20	68	2·8	3·7	1·9
30	20	72	3·4	4·7	2·2
35	20	78	3·9	5·5	2·5
40	15	83	4·8	6·0	3·6
45	15	86	5·5	7·0	4·3

Average Rainfall per annum.

London	25
South Coast	35
Cornwall and South West ...	45
Midlands	28–32
West Coast, Lancs., and Lake District	40–75

An inch of rain represents approximately 100 tons of water per acre.

TABLE 179

WATER

Daily Consumption in Gallons.

Cows in milk (for drinking)	8+2 approx. for each gallon of milk produced.
Heifers in calf	8 to 10
Calves	3 to 5
Cattle in yards	10
Horse in stable	6 to 8
Horse working	10
Pig	2
Sheep	1
Other purposes including milk cooling according to system	20
Cooling milk according to temperature ...	3 to 6 per gallon of milk cooled. N.B.—It may be possible to save this water fo other purposes.

Domestic purposes	30 per person. In rural areas this figure is rarely reached.

ELECTRICAL DATA—

A.C.	Alternating current. The direction of flow is reversed many times a second. National standard of frequency 50 cycles per second.
D.C.	Direct current. The current flows continuously in the same direction.
Ampere	(Amp.). The unit of electric current.
Ohm	The units of electrical resistance.
Unit	B. o. T. Unit. Board of Trade Unit—Equivalent to 1,000 watt hours.
Unit	British Thermal Unit. B.Th.U. One B.o.T. Unit—3,412 B.Th.U's.
Volt	The unit of electrical pressure. British standard for domestic and lighting purposes is 240 volts.
Watt	The Unit of electrical power. Volts × amps = watts. 1,000 watts equals one Kilowatt.
	British Thermal Unit (B.Th.U.) is the amount of heat necessary to raise the temperature of one pound of pure water one degree Fahrenheit.

TABLE 180

FENCING

Wire Gauges—Thickness in inches.

Gauge Number	English Imperial Standard Legal S.W.G.	Birmingham Old English Standard B.W.G.	Yards in cwt. solid S.W.G.	Yards in cwt. 7-ply stranded
1	·300	·300	160	200
2	·276	·284	190	220
3	·252	·259	228	260
4	·232	·238	269	307
5	·212	·220	322	392
6	·192	·203	393	465
7	·176	·180	467	546
8	·160	·165	566	700
9	·144	·148	700	800
10	·128	·134	900	1,000

Barbed wire—Difficult to climb, prevents cattle rubbing and pushing fence out of alignment. Not suitable where there are horses and should be out of the reach of sheep. Two-ply with two or four barbs.

TABLE 181

	Lengths and weight		
	Yards per cwt.	Weight per 100 yards	Weight per mile
		lb.	lb.
2 barbed 5 in. apart ...	590	19	335
4 barbed 6 in. apart ...	596	20	350
2 barbed 2½ in. apart...	530	21	370
4 barbed 3 in. apart ...	535	21	370

7-ply stranded wire. Very strong and suitable for dry inland areas.

TABLE 182

Gauge	1	2	3	4	5	6	7	8
Average lengths in yards per cwt.	205	230	265	325	380	480	560	675

Solid wire annealed. Suitable in most districts where atmospheric conditions render stranded wire unsuitable.

TABLE 183

Gauge	1	2	3	4	5	6	7	8
Average lengths in yards per cwt.	155	180	220	260	310	380	450	550

Aluminium Alloy—The spacing of wires will depend upon the class of stock to be enclosed or other protection to be afforded. Woven wire fencing should be galvanised after manufacture.

It is made in various gauges according to heights and spacings and 3 ft. to 5 ft. in height. Chain link fencing is made in various meshes and gauges of from 3 ft. to 12 ft. in height and from 1¼ in. to 4 in. mesh. Two straining wires are necessary for a fence 4 ft. high and an extra wire for each additional 2 ft. in height. Posts for the above fencing can be spaced at 8 ft. to 12 ft. apart. Wrot iron standards of flat, angle, T, or H section according to height above ground and number of wires required.

Straining posts must be adequately strutted and can be spaced from 100 to 200 yards apart according to nature of fence. The best methods of fixing wire to concrete posts are the wire tie method where a wire is put round the concrete post and secured to the fencing wire on either side of the post or by means of a wire staple passing through the post with its ends turned back against the post. Staples cast into the concrete posts during manufacture are not always satisfactory. Light steel droppers ensure wires maintaining their spacing and enable the fencing posts to be spaced further apart.

Reinforced concrete posts must be carefully made to ensure the proper protection of the reinforcement. Vibrated concrete is desirable. Timber posts other than oak should be creosoted under pressure although immersion particularly of the butts will prolong their life considerably. Particular attention must be paid to the quality of the creosote. Stockyard open timber fences should not be less than 4 ft. 6 in. high with the rails unless fixed, morticed into the posts on the stock side of the yard. The joints of rails to posts should be staggered, i.e., one row of rails should not be fixed to the same post as the rails above and below. Cleft Chestnut pale fencing is extensively used and can be obtained in heights varying from 2 ft. to 6 ft. in height with the pales at 1½ to 5 in. spacing.

The standard hurdle is 3 ft. and 4 ft. high by 6 ft. long.

Gates—The standard timber five-barred gate is 10 ft. wide by 4 ft. high. It must be carefully strutted or braced. Usual dimensions of the various members are, Heel 5 in. by 3 in., Head or closing style, 3 in. by 3 in., Top rail 5 in. by 3 in. tapering from heel to head to 3 in. by 3 in., Rails 4 in. by 1 in. or 3½ in. by 1 in. tapering to 3 in. by 1 in., Strut 3½ in. by 1 in. and braces 3 in. by 1 in.

Rails and braces should be bolted together with galvanised bolts. Oak, chestnut and larch are the most suitable timber. Hinges should be substantial and smith made and bolted to heel and top and bottom rails. Irons—fastenings, etc., should be substantial and the top rail should be strapped to head of gate. Hanging post not less than 8 in. by 8 in. by 8 ft. long and shutting post not less than 7 in. by 7 in. by 7 ft. long. The top of gates and posts should be weathered. Angle iron framed gates and galvanised tubular steel gates are gaining in popularity owing to the wider clear openings required for modern machinery. A width of 14 ft. to 15 ft. is considered sufficient. Hand gates should not be less than 4 ft. wide in the clear and 4 ft. high.

The provision of a hardcore or concrete apron at a gateway extending 6 ft. to 10 ft. on either side of the gate is an expense well worth while.

Cattle grids are gaining favour. These are best formed with dwarf concrete walls to the pit 12 in. to 18 in. deep, with 2 in. steel tubes or angle irons set at 5 in. centres running at right angles to the direction of the traffic. The number of intermediate sleeper wall supports for the tubes will depend upon the width of the grid and the class of traffic likely to use the grid. The tubes must be secured to prevent them being dislodged, although their rotation on their own axes is an additional deterrent to animals trying to cross the grid. Sleepers form a good base to which to fix the tubes. Wing fences can be constructed to slope out from the sides of a grid to prevent large or overhanging loads from fouling the fence.

Storage of Petrol and Oils. The storage of fuel oils is controlled under regulations and orders made under various Acts of Parliament which are administered by Local Authorities. The Local Authority should therefore be consulted before storage tanks for petrol and oils are installed.

TABLE 184

Approximate Overall sizes of the Farm Implements in general use.

	Length		Width		
	ft.	in.	ft.	in.	
Tractor	9	0	5	3	
Tractor Cultivator ...	7	0	7	3	
Horse Cultivator	7	6	7	0	
Horse rake	8	9	8	6	
Disc harrow	10	9	8	6	
Trailer	9	0	7	6	
Potato digger	8	9	4	0	
Potato spinner	10	6	5	6	
Ridging plough	10	6	3	0	
Furrow tractor	11	6	3	9	
Four furrow plough ...	18	0	6	0	
Horse ploughs, single ...	10	9	2	6	
Two-furrow	9	6	3	0	
Tractor	6	8	10	6	
Mower	8	6	10	6	
Manure distributor ...	8	0	10	9	
Combine harvester ...	22	2	10	0	× 10 ft. 2 in. high.
Bailer	22	6	9	3	
Combined grain & fertiliser drill	10	5	10	5	15 row.
			13	2	20 row.

GRAIN DRYING AND STORAGE

As long as the acreage of cereal crops grown in this country remains at the present level (6,397,000 acres) it can be expected that a minimum of 100,000 tons of grain will be harvested by combine each year.

TABLE 185

Approximate Nos. of combine harvesters at work in the U.K.

1934	1944	1946	1948	1949
50	2,500	3,460	6,800	9,000

The greater part of this quantity will probably be stored on the farm, the remainder, by millers or merchants or in National Grain Silos. It is considered to be in the farmer's own interest to store his grain until ready to sell, and in order to do this successfully, steps must be taken to prevent deterioration of the grain in storage.

FACTORS AFFECTING THE STORAGE OF GRAIN

1. **Moisture Content**—Cereal grains like all living organisms respire, producing heat, water and carbon-dioxide and it is the low level at which life is carried on that makes the grain stable in storage. If the moisture content of the grain is too high (Table 186) this stability is affected, the mass of grain becomes hot, is liable to be attacked by moulds and, if sufficiently damp, by bacteria.

2. **Pest Infestation**—The problem in this country is not so serious as in warmer climates but precautions should be taken to store grain away from possible sources of contamination, e.g., imported feeding stuffs. Insects and mites gain entry to farm buildings often in contaminated sacks. Once established in a building they hide in crevices where they can exist for considerable periods without food. Hollowed grains, matted surface on the grain mass, and the heating of grain that is dry enough not to heat through mould growth are usually signs of infestation.

3. **Other Kinds of Deterioration**—Loss of germinative power, loss of baking quality and nutritive value and other chemical changes may occur in stored grain and cannot be detected by visual inspection. Such deterioration is likely to occur if the grain has not been sufficiently dried in accordance with recommended temperatures (Tables 187 and 188).

TABLE 186

Moisture content limits for Safe Storage

For storage in Bulk	Moisture content should not exceed
duration of several months ...	14 per cent.
duration of under 1 month ...	16 per cent.
For storage in Sacks	
duration of several months ...	18 per cent.

Grain with a moisture content of up to 20 per cent. can usually be stored in sacks for periods of up to 4 weeks provided that sacks are stored only 1 row deep and are kept under observation.

MOISTURE CONTENT OF GRAIN HARVESTED BY COMBINE

The moisture content of grain taken from the spout of a combine is nearly always higher than that taken from a standing crop. This difference is greater when the sample contains a high proportion of green weed. The moisture content of grain may vary from 11 to 33 per cent. In trials carried out in Bedfordshire in 1948, 43·5 per cent. of the combine harvested grain contained more than 20 per cent. moisture and needed drying before it could be safely stored. In the same district in the exceptionally dry season of 1949 only 9 per cent. required drying.

FACTORS AFFECTING THE MOISTURE CONTENT OF GRAIN

1. **Weather conditions at harvest**—This is closely linked with the acreage to be harvested per foot cut of combine, since a farmer who has 20–25 acres per foot cut to harvest is in a better position to wait for favourable weather conditions than is the farmer who attempts 25–30 acres per foot cut.

2. **Presence of Green Weed Seed**—A small amount of green weed seed or unripened grain is sufficient to cause rapid heating in a sample of grain and the contaminants should be removed as soon as possible by passing the grain through a cleaner.

METHODS OF DETERMINING MOISTURE CONTENT

1. **Rough estimates** are reliable only after considerable experience of handling grain. One such method is to thrust the hand into a sack of grain. If the moisture content is high it is not possible to put the hand in much above the wrist; with dry grain the hand can be moved freely down the sack. A similar method can be applied in silos or to ventilate bins by pushing in a rod which moves freely through dry layers but not through damp.

2. **Moisture meters**—Those suitable for use on the farm are either electrical or work on the acetylene gas principle. (Calcium carbide absorbs moisture from a crushed sample of grain and produces acetylene gas in proportion to the amount of moisture absorbed. The mixing takes place in an airtight container and the pressure of the gas is indicated on a gauge calibrated in percentage of moisture.)

3. **Laboratory methods** for more accurate estimates include the Carter Simon oven method and the Brown Duvel oil-distillation method.

METHODS OF DRYING GRAIN

1. **Standard farm grain driers**—The method most commonly employed in this country is to pass hot air through a thin (3–6 in. thick) layer of grain. A high air velocity is used (50–70 cubic ft. air per minute). All grains are very sensitive to heat, and germinative and baking qualities are easily destroyed by the use of high temperatures. Table 187 gives the limits for hot air temperatures used when drying various classes of grain (N.I.A.E.) :—

TABLE 187
Hot Air Temperature Limits

Oats and dredgecorn (except for seed)	180° F.
Wheat for milling	150° F.
Barley and seed corn up to 24 per cent. moisture ...	120° F.
Barley and seed corn over 24 per cent. moisture ...	110° F.
Linseed, mustard and other oily seeds	115° F.

Standard farm grain driers fall into two classes (*a*) horizontal or tray types in which grain lies on one or more perforated tables and is moved along by moving bars or by reciprocation of the table and (*b*) the tower or vertical type in which grain falls in narrow columns between perforated walls. Before leaving the drier it is necessary for grain to be cooled to a temperature not greater than 10° F. above that of the atmosphere and driers should have a cold air, as well as a hot air section.

In earlier models heat was generally supplied by a coke furnac but oil burners are now favoured as these are more suited t thermostatic control. Electricity is seldom used as a source of he due to the present high costs and the difficulty of supplying hig loads for comparatively short periods of time. Farm grain drie are rated according to their throughput when removing 6 per cen moisture using a hot air temperature of 150° F. Outputs rang from 1–3 tons per hour and the rate of throughput controls t moisture content of the final sample, i.e., the greater the amou of moisture to be removed from a sample of grain the mo slowly must it pass through the drier. When dealing wi samples of very damp grain it is often advisable to run it throug the drier twice ; the first time to reduce the moisture sufficien to permit safe storage until time permits a second drying. T hot air temperature *must* be kept constant, and the moistu content of the dried grain varied by changes in rate of throug put.

To estimate the rate of delivery needed to obtain dried gr with a particular moisture content, the following method c be adopted.

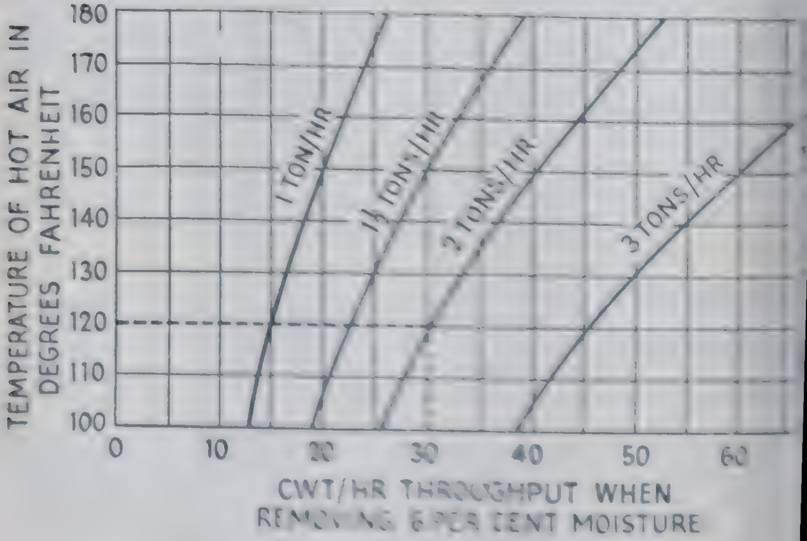


Fig. 28 (N.I.A.E.)

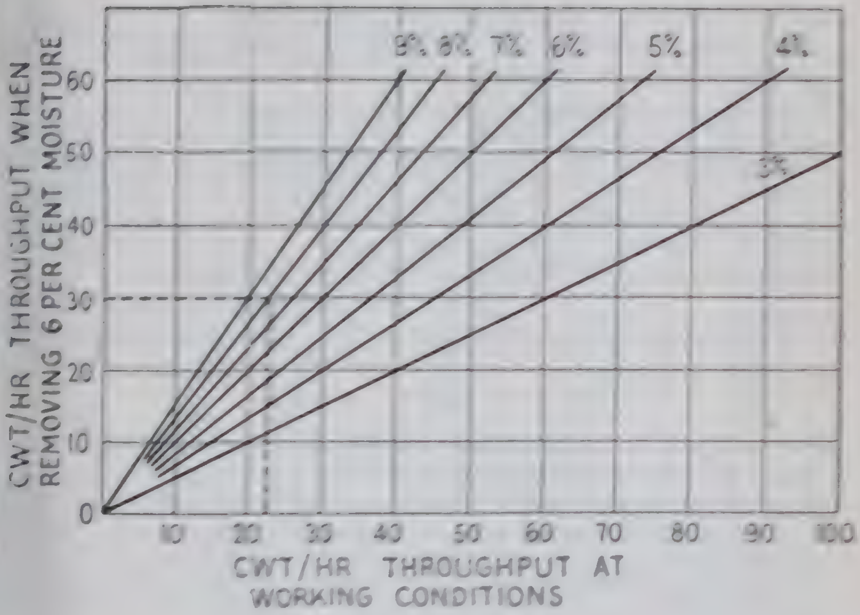


Fig. 29 (N.I.A.E.)

Given (i) a drier of capacity 2 tons per hour at moisture removal of 6 per cent., hot air temperature 150° F.

(ii) a sample of grain at 24 per cent. moisture which it is desired to dry at a temperature of 120° F.

Required to find the throughput rate at which the drier must work in order to reduce the sample by 8 per cent., i.e., to achieve a final moisture content of 16 per cent.

Taking Fig. 24—A drier discharging at a rate of 40 cwt. an hour when removing 6 per cent. moisture at the standard hot air temperature of 150° F. must be set to discharge 30 cwt. an hour to remove the same amount of moisture when working at the required temperature of 120° F.

Taking Fig. 29—Given that a discharge rate of 30 cwt. per hour will remove the standard 6 per cent. moisture, this graph shows that a discharge rate of 22½ cwt. an hour must be used to reduce the moisture content by 8 per cent.

In the absence of a moisture meter the humidity of the air leaving the drier is a good indication of the grain moisture. This humidity can be measured by the difference between the temperatures of the air entering and leaving the hot air section of the drier. (The two thermometers must be suitably placed to give true entry and exit temperatures.)

TABLE 188 (N.I.A.E.)

Relationship between exit temperature and Grain Moisture

3-inch grain thickness		6-inch grain thickness		Final moisture content per cent.
Drying temperature		Drying temperature		
165° F.	140° F.	165° F.	140° F.	
	Exit Thermometer Readings			
130	133	119	133	14
125	120	112	114	15
120	114	105	105	16
116	109	102	100	17
113	106	98	95	18

Some variation in the above figures may occur for different types of driers but with a little experience it is possible to judge the dryness of the grain quite accurately by this method. Once grain of the correct dryness has been obtained the aim should be to keep the level of the exit thermometer constant ; if it falls the rate of discharge should be decreased ; if it rises the rate should be increased.

2. **Drying grain in sacks**—This method has been used for some years on the continent, but until recently was not practised to any great extent in this country. A plant suitable for drying grain in 1 cwt. hessian bags has been developed ; air is heated to 25° above atmospheric temperature and blown (5,700 cubic fee per minute) through ducting to pass underneath a platform on, which sacks are resting, each sack covering a hole in the platform and supported on a grid. Such plants can be designed in various shapes to fit into existing buildings and one plant can accommodate up to 40 sacks. Moisture is removed at the rate o 1 per cent. per hour, and the low temperature used makes it a safe method of drying. Little supervision is required, labou being needed chiefly to move the sacks after drying and to put o the next load.

3. **Drying grain in ventilated bins by the use of slightly warme air**—In bin drying, warmed air (60 per cent. relative humidity is blown through a porous floor and passes slowly upwards an through the grain mass, drying from the bottom of the bi upwards at a rate of 1 per cent. moisture removal per 24 hour ventilation. It may therefore be some time before the top layer are dried, and for this reason the bins should not be more tha 10 ft. in depth or grain may start to mould before it can be drie Similarly, such a system is not suitable for districts where

large quantity of grain is harvested with a moisture content over 21 per cent. The system has the advantage of combining drying and storage in one plant. The operations require little supervision.

The average relative humidity of the British atmosphere is generally too high to permit the use of untreated air in reducing the moisture content of the grain to a safe level except at certain periods of the day (around mid-day in good weather). It is therefore necessary to dry the air by warming it 8–10° above ambient temperature. Other methods have been suggested for drying air—such as passing it over a desiccant—but this work is still in the experimental stage.

The chief points concerning the three drying methods described are summarised in Table 189.

TABLE 189

Comparison of three methods of drying grain

	Standard Drier	Drying in Sacks	*Drying and storing in ventilated bins
Hot air	115°—180° F.	80°—90° (25° above atmospheric temperature)	75°—80° (10° above atmospheric temperature)
Rate of moisture removal	1 per cent. in 8–10 mins.	1 per cent. per hour	1 per cent. in 48 hours
Amount that could be dried by 6 per cent. in 12 hours	12–24 tons	4 tons (on a 40 sk. plant)	The moisture content of the grain in each bin being ventilated would be reduced by .25 per cent. in 12 hrs.
Fuel consumption per ton of grain dried :—			
diesel oil	—	3.0 gallons	—
vapourizing oil ...	2½ gallons	—	—
coke	28 lb.	—	—
electricity ...	—	—	17 units (heat) 23 units (power)
Power	6–20 h.p.	3½ h.p. (max.)	10 h.p.

	Standard Drier	Drying in Sacks	*Drying and storing in ventilated bins
Labour requirement	1 man full-time	2 men for loading and unloading sacks	1 man when filling bins. Short inspection 4–5 times daily
Approximate cost of installation	£1,000—£3,000	£350—£450	£1,600 for 250 tons (including storage)

* These figures are based on results of observations made on a 6-bin plant with total capacity 150 tons.

4. **Emergency Methods of Drying**—A certain amount of drying takes place if a heap of grain is turned on the barn floor with a shovel. The method is laborious and can only be used for small quantities in danger of spoiling. A similar method on a larger scale turns the contents of one bin or silo into another by means of pneumatic elevation. Passing grain through a cleaner also brings about a reduction in moisture by removal of green weed and seed. Grain stored in sacks also dries appreciably provided the sacks are stored only one layer deep and with air channels between rows. In the case of grain with a moisture content approaching 20 per cent. and above, none of these methods is adequate and some form of artificial drying is required.

METHODS OF STORING GRAIN

1. **Storage in Sacks**—This is usually restricted by shortage o sacks and space to put them when full, and one of the chie obstacles is that it is difficult to make a sack store vermin proof

2. **Storage in bulk**—For large quantities of grain some form of bulk storage is required and the amount of mechanica handling can then be considerably reduced. Grain stored in silos should be carefully watched, and if any signs of heatin occur the grain should be turned from one silo to anothe Heating may occur with the rise of atmospheric temperature i spring, particularly if the grain has not been evenly dried to moisture content of 14 per cent. Iron rods kept permanently i the bulk of grain will give a useful indication of any such rise i grain temperature. Silos can be fitted with self-emptying hoppe but this usually increases the cost by at least 10 per cent. Whe occupies 45 cubic feet per ton, barley 50 cubic feet per ton ar oats 66–80 cubic feet per ton. The cost of precast concrete sil is high and works out at from 5/- to 9/- per quarter.

3. **National Grain Silos**—There are 16 of these silos situated in various parts of the country. Each plant consists of 2 driers (total capacity 10 tons per hour) and storage for 5,000 tons of grain—a total of 80,000 tons.

ADDITIONAL EQUIPMENT

In addition to a grain drier the following accessories are generally required :—

1. **Receiving Hoppers**—As the grain drier is able to work very much longer hours than the combine it is useful to have a large intake hopper so that drying can proceed when it is not possible to continue work with the combine. A large hopper is particularly necessary when handling grain in bulk rather than in sacks and if possible the hopper should be able to hold at least 4–5 hours output from the combine. The capacity of a hopper can be calculated as follows :—

$$\text{vertical sided part} \quad \frac{\text{length} \times \text{breadth} \times \text{depth (ft.)}}{5} = \text{No. of 4 bushel sacks.}$$

$$\text{sloping sided part} \quad \frac{\text{length} \times \text{breadth} \times \text{depth (ft.)}}{15} = \text{No. of 4 bushel sacks.}$$

The sides should slope at not less than 45°.

2. **Cleaning Equipment**—Many farm driers have a built-in precleaner which takes out the worst of the rubbish before the sample is dried. A final cleaning and grading is usually given in a more elaborate type of cleaner, before final sacking off for sale.

3. **Conveyors**—Where grain is handled or stored in bulk it is convenient to install a conveying system to carry grain from the receiving hopper to the sacking-off chute, passing through or by-passing as many of the intermediate stages (drier, cleaner, storage silos or bins) as is required. Mechanical conveyors are useful for conveying on the horizontal plane, and in some cases can also elevate vertically or at a slope of up to 15°. Where it is desired to convey grain round corners and bends, a pneumatic system is very useful, particularly if the fan unit is portable. Pneumatic elevators require rather more power than the mechanical types.

LABOUR

Horses or Tractors required on Mixed Husbandry Farms—Two horses for 50–80 acres or one tractor for 70–120 acres, the higher acreage on the larger farms, and in the south and east where a considerable area of corn is sown in the autumn and the climate is drier than in the north and west.

A tractor in this section, is understood to be the medium powered, wheeled machine capable of pulling a three-furrow plough on medium soil at a speed of 3 m.p.h., cutting furrows 12 in. wide by 6 in. deep.

On large tillage farms and where much deep cultivation is done on loose soil high powered tracklaying tractors are used.

Rate of working of implements—

Ploughs :

Rate of working in acres per hour =

$$\frac{\text{Working width in feet} \times \text{speed in m.p.h.}}{18}$$

Other implements :

Rate of working in acres per hour =

$$\frac{\text{Working width in feet} \times \text{speed in m.p.h.}}{10}$$

These formulæ make adequate allowance for setting out of fields, turning at the headlands, making adjustments, etc.

Cultivations

The main purpose is to produce a tilth suitable for the growth of crops, destroy weeds or drag them to the surface and to aerate the soil and distribute manure. All cultivations should be done when the soil is in good working condition, otherwise soil structure may be destroyed.

Digging—To dig an acre of land from 9-12 in. deep with a spade, will take a man 16-24 days on easily moved soil. Old turf or difficult soil will take in some cases double the time.

Plough—Performs the fundamental cultivation in agriculture. Moves all soil to full depth, buries manure, stubble and weeds and exposes fresh soil for weathering.

The draught of a plough is expressed as lb. per square inch of furrow slice cross section, and for soils in good ploughing condition are :—

	lb. per sq. in.
Sand and sandy loam ...	5–8
Loam	9–11
Clay loam	12–14
Clay	14–16

Area ploughed—2-horse team, 10 in. furrow—0·07–0·10 acre per hour. Tractor, 10–12 in. furrow—0·14–0·20 acre per hour per furrow.

Cultivators and Harrows—Break up the plough furrows and work the soil to a tilth in the preparation of seed beds. Destroy weeds, cover seeds and mix fertiliser with soil.

Rigid and spring-loaded tine Cultivators—Used for cultivating to full plough depth. Have very little pulverising effect on the soil.

Area covered—Tractor with 9–11 tine cultivator—1·00–1·50 acres per hour.

Spring-tooth Cultivator—Pulverises the soil from 3–4 in. deep and brings weeds to the surface. Useful on land infested with such weeds as couch grass.

Area covered—2-horse team, 2 leaves—0·75–1·00 acre per hour. Tractor, 3 leaves—1·75–2·25 acres per hour.

Disc Cultivator—Each disc acts as a miniature plough body. Produces a fine tilth and is particularly useful on newly ploughed grassland. Should not be used on land infested with couch grass, docks, etc.

Area covered—Tractor with double discs, 8 ft. wide—1·75–2·25 acres per hour.

Rotary Cultivator—A very fine loose tilth is produced in one operation in suitable conditions but weeds and trash are not completely buried.

Area covered—Tractor with power take-off driven rotor 3–4 in. deep—0·50–1·00 acre per hour.

Harrows—Used for surface cultivation, covering seeds and partial consolidation. Tractor harrows should be heavie than those for horse work to prevent bouncing due to greate speed.

Area covered—2-horse team with 7 ft. harrow—1·25–1·50 acres per hour. Tractor with 18 ft. harrows—5·00–6·00 acre per hour.

Rolls—Crush moderately dry clods, consolidate the soil and smooth the surface.

Area covered—1 horse with 6 ft. roller—1·00–1·25 acres per hour. Tractor with 8 ft. roller—1·50–1·75 acres per hour. Tractor with 3-gang roller, 16 ft.—4·00–5·00 acres per hour.

Row Crop Cultivation—*Ridging and splitting back*—2-horse team with ridging plough—0·35–0·40 acre per hour. Tractor with 3-row ridger—1·00–1·25 acres per hour.

Cultivating and hoeing—Single row horse hoe or cultivator—0·35–0·40 acre per hour. Four-row steerage horse hoe with man and boy—1·00–1·25 acres per hour. Tractor with rear mounted steerage toolbar, 2 men, 4-row—1·50–2·50 acres per hour. Tractor with toolbar, 3-row—1·50–2·00 acres per hour.

Fertiliser Distribution—1 horse, 1 man and 9 ft. distributor, up to 10 cwt. per acre—1·00–1·50 acres per hour. Tractor and 1 man—0·15–0·25 acre per hour per foot width of distributor. Lime from manure distributor, 25 cwt. per acre—0·75–1·00 acre per hour. Lime by shovel from cart, 2 tons per acre, 2 men—0·5 acre per hour.

Sowing and Planting. *Broadcast*—By hand, with man or boy to carry—1·25–1·50 acre per hour. By machine with horse or tractor—0·20–0·30 acre per hour per foot width. Grass seed by hand barrow—1·50–2·00 acres per hour.

Drilling—Corn and simular crops: 2-horse team and 2 men—1·00–1·50 acre per hour. Tractor and 2 men—0·20–0·30 acre per hour per foot width of drill. *Row crops*—2-row ridge drill—0·75–1·25 acres per hour. Four-row drill on flat, horses or tractor and 2 men—1·50–2·00 acres per hour.

POTATOES. *Hand planting, 3 acres per day—farmyard manure ploughed in*—Two 2-horse teams with teamsmen or tractor and driver with 3-row ridger and front coverer. One man, 1 horse and cart and fertiliser distributor to cart "seed" potatoes to field and distribute fertiliser. Six to seven workers to plant "seeds" (8–10 if chitted seed in trays).

If farmyard manure is applied in the ridges the following additional labour will be required :—4 men, 4 horses and carts to cart farmyard manure from dungstead or 4 men (2 loading), 2 tractors and 3 trailers (up to ½-mile with horses, 1 mile with tractors).

Machine planting—Area covered depends on spacing between "seeds." Three-row planter, opening and closing ridges, and distributing fertiliser, with tractor and driver, and 3 operators 4·6 acres per day.

TRANSPLANTING—2 men, with boy to carry—about 2,000 plants per hour. Two-row hand fed transplanting machine, 3 operators (one to bunch plants) with tractor and driver—3,000–4,000 plants per hour.

Machine sets plants more firmly than by hand but the rows cannot be cross-cultivated.

THINNING PLANTS—Area covered depends on density of plants, tilth, weeds and distance between rows.

Mangolds, swedes and kale—1 man in favourable conditions—0·20–0·25 acre in 8 hours. *Sugar beet*—0·15–0·20 acre in 8 hours.

SPRAYING—Two men and tractor sprayer with 15 ft. boom and power operated pump for filling (water available in the field)—3 acres per hour.

Harvesting. HAY—30 cwt. per acre.

Mowing—2-horse team, 1 man with 4½–5 ft. mower—0·8 acre per hour. Tractor with adapted horse mower, 2 men—1·00–1·25 acres per hour. Tractor with 6 ft. mower, 1 man—1·5 acres per hour.

TABLE 190

Making : turning, raking, cocking and tripoding—

Method or equipment	No. of men	Rate of working acres per hour
Horse and side rake	1	1·6
Tractor and side rake	1	2·2
Horse and dump rake	1	1·8
Tractor and dump rake ...	1	2·25
Hand turning	1	0·4
Hand cocking	1	0·6
Sweeping to tripod	1	1·8
Setting Tripods and tripoding ...	1	0·3

Cocking from windrows—60 lb. per cock.

On tripod—600–800 lb.

Mowing to Storage—

TABLE 191

	No. of men	Tons per hour	Acres per hour
Hand loading to cart	3	2·0	1·25
Hay loader	2	1·5	1·00
Sweeping to stack from windrows (up to 400 yards) ...	1	1·2	0·80
Pick-up baler (hand tied) ...	3	1·5	1·00
Pick-up baler (automatic tying)	1	3·0	2·00
Collecting and storing bales ...	3	1·5	1·00
Horse rick lifter (½-mile haul)	1	1·0	0·66
Tractor power rick lifter (½-mile haul)	1	2·2	1·46

Average rate of travel to and from field :—Horse and cart 2·5 m.p.h. ; tractor and trailer 5 m.p.h. ; motor truck 5–15 m.p.h.

SILAGE. *Mowing*—Tractor and mower—1·00–1·50 acres per hour. *Pit silo within 400 yards of crop*—2 men with 2 tractors and trailers, 2 men loading from windrows and 1 man at silo—14–16 tons or 2 acres in 8 hours. Two men with 2 tractors and trailers, and crop loader, 1 man building loads and 1 man at silo—14–16 tons or 2 acres in 8 hours.

1 man with tractor and buckrake and 1 man at silo—10–11 tons or 1·75 acres in 8 hours.

Tower silo—1 tractor and cutter blower and 3 men would be required in addition to any one of the above gangs.

CORN. *Cutting with binder*—2 horses with 4½ ft. binder—5 acres in 8 hours (standing corn). One tractor with 6 ft. binder—10–12 acres in 8 hours (standing corn).

Stooking—2 men—4–5 acres in 8 hours.

Carting and stacking—6 men, with 1 tractor and trailer and elevator stacking in the field—1 acre per hour.

Thatching—Small round stack containing 2 acres, 2 men—3 hours. Stack containing 10 acres, 1 man—about 2 days.

Threshing—Tractor with 4 ft. 6 in. thresher and trusser—

Pitching sheaves from stack to feeding board	3 men
Cutting bands	2 men
Feeding (if self-feeder not fitted)	1 man
Pitching trusses of straw to stack	2–3 men
Building stack	2 men
Removing chaff and cavings	1 man
Sacking and weighing grain	2 men

Output—30–40 cwt. grain per hour.

Tractor, 4 ft. 6 in. drum and baler with gang of 8–10 men—output 20 cwt. grain per hour.

American Peg Drum thresher with feed elevator, mechanical band cutter and straw, cavings and chaff blower with gang of 3–4 men—output 20–30 cwt. grain per hour. The straw is broken and difficult to handle.

Combine Harvester—

North of England and Scotland	18–22 acres per foot of cut per season.
South of England	20–25 acres per foot of cut per season.

Average standing crop in good dry conditions	0·125 acre per foot of cut per hour.
Grain delivered to sack	2 men.
Grain delivered to tank	1 man.
Carting off sacks ...	2 men with tractor and trailer.
Carting from tank ...	1 man with tractor and 2 grain tight trailers.

If tank is emptied while combine is moving an additional man and tractor are required.

POTATOES—To lift about 0·50 acre per hour or 3 acres per day :—

Gang required—Digging—1 man with tractor and spinner. Lifting—20–24 pickers working two sides, and overseer. Transporting to clamp—2 men with 2 tractors and trailers and 4 men to load. Clamping—3 men.

If an elevator digger is used fewer pickers are required and more potatoes may be lifted.

ROOTS. *Mangolds, swedes, etc.*—Lifting, 1 man—0·25–0·30 acre per day. Carting—1 man with horse and cart—0·25–0·30 acre per day.

Kale—Cutting and loading, 1 man—0·75 tons per hour. Forage harvester—12–14 tons per hour.

Loading Carts—A good workman can load 25–30 cwt. per hour into a cart or trailer. He can load 8 cub. yd. of chalk, 10 of clay and 12 of loam sand or gravel in one day.

Dairying—1 man is required for every 20 cows in a self-contained herd *milking*—

By hand—A good milker can milk 12 cows per day, night and morning ; 6–8 cows per hour.

By machine—2 units ; up to 30 cows per day, night an morning.

Fattening Cattle—1 man can attend to 40 bullocks if house in convenient yards.

Sheep. *Shepherding*—1 shepherd can attend to 500–70 sheep on open land, 200 if in folds, with additional help a lambing.

Shearing—Short wool sheep, 14–18 ; half-bred, 30–40 ; an blackface, 80–100 in a full day.

TABLE 192
COST OF LABOUR BY CONTRACT, 1950

	Per acre		Per hour	
	s.	d.	s.	d.
Tractor ploughing	30s.–32s.		14	0
Tracklayer and deep digging plough ...	40	0	20	0
Tracklayer and Prairie Buster	45	0	21	0
Cultivating	11	6	16	0
Discing	10	6	15	6
Rolling	5	3	11	6
Fertiliser distributing	12	6	16	0
Drilling grain or seeds	13	9	17	6
Drilling grain and fertiliser	15	9	20	0
Binding corn	21	0	21	0
Mowing	15	9	13	3
Combine havesting—12 ft.	—		86	0
8 ft.	—		65	0
Hay raking, swath turning, sweeping or tedding	—		15	0
Baling—Baler, tractor and 1 man ...	—		25	0
Pick-up baler (hand tying) ...	—		6d. per bale	
Pick-up baler (automatic tying)	—		31	6
Green crop loading (tractor and 1 man)	—		18	0
Tractor and buckrake	—		15	0
Tractor and cutter blower (silage) ...	—		20	0
Potato planting (excluding gang labour)				
2-row machine	—		17	6
3-row machine	—		22	6
Potato ridging	—		17	0
Potato lifting (excluding gang labour)				
With spinner	—		13	6
With elevator	—		14	6
Tractor and threshing machine... ...	—		25	0
Tractor and earth scoop	—		15	0
Bulldozing — Large tracklayer and angledozer	—		40	0
Bulldozing — Small tracklayer and angledozer	—		52	

SILAGE PITS—A trench 4 yd. wide at bottom, 5 yd. wide at ground level, 1½ yd. deep and about 24 yd. long, including ramps, will hold 100 tons of silage.

EXCAVATION—

Up to 50 tons pit	£10
,, 100 ,, ...	£15
,, 150 ,, ...	£20
,, 200 ,, ...	£25

DRAINING. *Mechanical trencher—Roteho* :—

	per chain s.	d.
Excavation 3ft. deep...	12	0
Crumbing	1	6
Laying tiles	5	0
Backfilling	2	6
Total ...	21	0

By hand labour :—

	per chain s.	d.
Digging, 30 in. deep	23	0
Laying tiles	5	0
Back filling	5	0
Total ...	33	0

Hill Draining—Cuthbertson Hill Draining Plough—1s. 9d.-2s. 6d. per chain.

Contract rates are high as they have to cover difficult tasks, travelling or lodging, lost time and a reasonable return to the contractor.

Cost of Labour on the Farm—This table is based on a tractor and implement costing the farmer 4s. 6d. and driver 2s. 6d. per hour working time. A pair of horses and implemen 3s. 6d. and horseman 2s. 6d. per hour working time.

TABLE 193

	s.	d.	
Loading farmyard manure	2	0	per ton.
Carting farmyard manure (1 mile)... ...	5	0	,,
Spreading farmyard manure	1	10	,,
Ploughing—horses	55	0	per acre.
tractor	20	0	,,
Cultivating by tractor once	6	0	,,
Discing once	5	0	,,
Harrowing—horses	5	0	,,
tractor	2	6	,,
Rolling—horse	6	0	,,
tractor	2	0	,,
Distributing fertiliser	7	0	,,

	s.	d.	
Distributing lime	5	0	per ton.
Drilling corn—tractor	7	6	per acre.
Sowing seed by hand	4	0	,,
Sowing grass seed—barrow	3	0	,,
Potato planting—hand	35	0	,,
Setting plants	6	0	per 1,000.
Hoeing—horse	11	0	per acre
tractor (4-row)	5	6	,,
Hoeing roots—thinning	80	0	,,
sugar beet (piece work)	1	4	per 100 yd. of row.
Mowing grass	8	0	per acre.
Horse raking	2	0	,,
Hay cocking and rucking	6	0	,,
Reaping—hand	70	0	,,
binder—horses	15	0	,,
tractor	10	0	,,
Stooking	10	0	,,
Thatching stacks	6	0	per sq. of 100 ft.
Threshing oats	6	0	per qr.
Threshing wheat	8	0	,,
Potato lifting—hand	240	0	per acre.
digger	150	0	,,
Root lifting—turnips	76	0	,,
swedes	84	0	,,
mangolds	120	0	,,
sugar beet	1	4	per 100 yd. of row.
Milking	0	8	per cow daily.
Sheep—dipping	0	6	per sheep.
shearing	20	0	per score.
Draining—2 ft. 6 in. cutting and filling	22	0	per chain.
3 ft. mains cutting and filling	28	0	,,
cleaning out ditches	22	0	,,
Hedges—trimming (two sides)	5	0	,,
laying	7	6	per pole.
setting quicks	10	0	,,
cleaning	10	0	,,
Stone dyking	15	0	per lin. yd.
Thatching cottages	40	0	per sq. of 100 ft.

TABLE 194
COST OF LABOUR PER ACRE IN TERMS OF DAYS WORK

	Root Crops		Corn Cro	
	Man	Tractor	Man	Tr.
Autumn ploughing once ...	0·40	0·40	0·40	0
Spring ploughing once ...	0·30	0·30	—	
Cultivating or discing twice	—	—	0·20	0
Cultivating or discing three times	0·30	0·30	—	
Harrowing twice	0·10	0·10	0·10	0
Rolling once	0·03	0·03	0·03	0
Dung carting, 20 loads per acre	2·00	1·00	—	
Dung spreading, 20 loads per acre	1·50	—	—	
Sowing artificials	0·10	0·10	0·10	
Ridging—opening and splitting	0·25	0·25	—	
Sowing seed	0·10	0·10	0·20	
Singling roots	4·50	—	—	
Hoe—cultivation	0·10	0·10	—	
Reaping and binding ...	—	—	0·20	
Stooking ...	—	—	0·50	
Pitching, carting and stacking	—	—	1·00	
Thatching	—	—	0·20	
Threshing (men only)	—	—	1·60	
Lifting roots	4·00	—	—	
Carting roots	2·00	1·00	—	
	15·68 at 18s.	3·68 at 36s.	4·53 at 18s.	
Add 25s. for hire of threshing machine and 20s. for extra wages, harvest and threshing			£1 0 0	£
	£14 2 3	£6 12 6	£4 1 6	£

A man is reckoned at 18s. and a tractor and imple 36s. per day. To these prices should be added 25 p to cover the proportionate cost of "non-productive on the farm in the shape of hedging, ditching, repairs which must all be reckoned in the total expenses.

ONTH BY MONTH ON THE FARM

JANUARY

eather, etc.—Normally the coldest month of the year with ost frequent, longest and hardest frosts. Mean temperature) lowest in the 2nd week, 37° F. in the Midlands rising to F. in the 4th week. With only 1–2 hours bright sun-, day and night temperatures differ by only 10° F. Plant th nil or due to "unseasonable" weather and not liked by ers. Signs of the turn of the year—snowdrops, coltsfoot, , hazel catkins. Birds begin to sing.

able—Finish arrears of December ploughing—(i) stubbles rain crop; deep if not manured, shallow if manure already ned deeply; (ii) root land for spring corn—shallow to l bringing up annual weed seeds. Plough leys for spring . During frosty weather cart out yard manure for spreading urface of ploughed land or between ridges. Fertilisers, ding sulphate of ammonia, may be covered with yard ure without loss of nitrogen, soil being too cold for nitri-ion. When soil conditions permit, sowing of cereals may be ued—winter wheats and hardy varieties of oats and barley: shallow, add superphosphates, protect against birds.

assland—Avoid grazing fields intended for early spring ing. Harrow and roll after removal of stock. Apply lime, phates and potash. Severe surface cultivations of rough ds. Mow-meadows and "seeds" for hay may receive d manure or any dung apportioned to them; often grass carry vehicles when arable land is too soft. Some pulling tling of water meadows.

vestock—All young cattle for which buildings are available now housed or yarded. Accommodation and litter supplies t but desirable that cattle under 1½ years old run loose in s or large boxes. In-calf heifers usually tied in stalls. y balancing of feeds for steady economical growth of 1 ½ lb. daily. Watch for symptoms of ringworm, lice and rinal parasites; provide salt. Autumn-born calves when ed off milk or proprietary milk substitutes require cod liver nd minerals. Cattle wintering-out now depend mainly, n hard weather entirely, on fodder, etc. supplied. Hay is place of straw when little green bite available. Feed in the morning for contentment. Dairy cows now on rations not including kale or cabbage require other source of protein for maintenance—silage or good hay. October calvers now due for service ; releasing for exercise and observation. Under-fed or unsuitably fed bulls may have poor fertility. Ewes in-lamb for March require hay and about ½ lb. of crushed oats, or cake if on roots, to ensure steady growth and avoid pregnancy toxæmia. Sows due to farrow next month should be brought into suitable condition for milk production.

Machinery—Prevent frost damage to tractors and other water-cooled engines. In frosty weather avoid breakages by releasing moving parts of dung spreaders, drills, etc. before filling. Overhaul tractors during idle periods.

Other Work—As in December. Planting of fruit trees, bushes and quicks. Winter spraying of fruit trees.

FEBRUARY

Weather, etc.—The days lengthen, morning and evening twilight periods begin to draw out and by the 15th daylight extends from 7.0 a.m. to 5.30 p.m. Sometimes February is a wet month and occasionally snow lies for long periods, but on the average of years this ranks as a month of low rainfall : a considerable area on the eastern side of England has an average rainfall of less than 2 in. Mean temperatures are 39° F. in the Midlands, but with the increase in bright sunshine there are signs of the resumption of vegetative growth, first in the hardy plants—flowers of snowdrop, crocus, early primrose, violets, gorse and the leaves of daffodils and narcissi, and in mild spell the drill rows of cereals sown in December and January suddenly show green. Larks and blackbirds begin to sing on warme days.

Arable—The possibility and extent of major field operation depend on weather and soil conditions, progress on light soils in dry eastern districts often becoming far ahead of that elsewhere Spring beans are ploughed under a 4 in. furrow. Sprin wheats are sown when soil conditions permit : where competition with annual weeds is expected, combine-drilling of see and fertiliser is advantageous. Winter vetches, peas, hard varieties of oats (Black Supreme, winter varieties) and hard barleys (e.g., Pioneer, Plumage Archer) may be sown ; ley lan usually dry enough for sowing before stubble or root lan Apply phosphates and potash with seed but may be advisabl to keep back nitrogen until April. February sowings subject t damage by rooks and pigeons. Heavy land intended for green crops should be deeply cross-ploughed in February, unless already done. Manure carting continues, on to the ploughed land, or between the ridges, in frosty weather. Fertilisers may be sown on manure between ridges and the ridges split when conditions permit. About February 21st–28th, apply nitro-chalk to rye or Italian ryegrass intended for first cut of silage fodder. Under suitable conditions winter cereals may be utilised for March–April grazing if suitably top dressed about the end of February.

Grassland—General operations as in December and January. Apply phosphates and potash to mowing land, including clovers. Selected fields or sections intended for early bite receive nitrogenous top dressings about 25th—2–3 cwt. of nitro-chalk. Mole draining may begin when top soil dry enough to carry the tackle but subsoil moist.

Live Stock—Milk supplies decline between January and March: autumn calvers have passed their flush, spring calvers are dry and relatively few cows calve in February. Mixed milk of the herd tends to decline in content of non-fatty solids, particularly the protein. Effects of winter housing conditions and rations now visible—bruises, swellings and bald patches ; underfed or unthrifty cattle noticeable, and casualties increase. Outwintering in-calf heifers, especially younger ages, apt to lose condition, unless receiving extra rations ; may be better brought indoors. Examine in-lamb ewes for condition. Loss of flesh during hard weather in February predisposes to pregnancy toxæmia. Well fed ewes produce larger lambs and suckle them better. Newly born lambs may require assistance to teat in cold weather, and may have to be confined to lambing pens for a week or two. February litters of pigs require protection from chills, which are an important cause of anaemia.

General—Check over supplies of fodder in relation to requirements for remaining half of the winter-feeding period. Complete plans for spring sowings and manuring—varieties of spring corn, mixtures of grass and clover seeds, etc. ; review orders for supplies. Dress seed corn for leaf stripe. Empty manure holds and clean out loose boxes, stacking manure in the fields when land too wet to carry vehicles. Repair fencing and erect fences for close grazing.

MARCH

Weather, etc.—March has the extended daylight and bright sunshine of the spring months but has the winter characteristics of cold mean temperature, frequent night frosts and occasional falls of snow. Proverbially windy and changeable, March is the

middle month of the least rainy quarter of the year, when th
normal monthly rainfall in the eastern and midland area i
under 2 in. Relative humidity is now low, so that soil begin
to dry out and drains cease to flow. Vegetative growth is stil
slow at the beginning of the month with mean temperature 40° F
but by the end, at 43° F., there is a considerable show of flowers
crocus, daffodil, narcissus, scylla, grape hyacinth, polyanthus
japonica, forsythia, almond ; and the hedgerows show bits o
green. Rye is now 6 in. high, wheat begins to move and after
mild spell grassland freshens. Rooks are building and son
birds are noisy in the early morning.

Arable—Complete the sowing of spring cereals after le
Where wireworm is present use protective seed dressing and
possible combine-drill the seed with 2 cwt. per acre supe
phosphate. Finish ploughing for cereals after green crop–
shallow to avoid raising weed seeds. Choose varieties with sti
straw, especially when to be underseeded, in which case pho
phates and potash may be applied to seed bed but no nitroge
until late April. Give priority to oat sowing to avoid frit fly
next wheat, but after 15th prefer Fylgia to Atle or Berse
Barleys can be sown late if necessary. Dredge and blendin
corn sown. Grass and clover seeds are most likely to succee
under winter wheat and spring oats if sown early. Under barl
may be sown later. Where annual weeds troublesome, ac
spraying may be necessary and seeding delayed till Apr
Autumn sown cereals are harrowed and rolled when surfa
dry enough. Thin stands (causes ?) of wheat may recei
nitrogen. Partial failures may be patched with Atle or Fylg
Land for potatoes next dealt with. On heavy, moist soils
further deep ploughing is necessary to expedite drying a
enable ridger to work, but clod formation must be prevente
Begin planting, proper depth of covering about 4 in. If se
not all sprouted, reserve these for next batch. Emphasis
new seed and early planting. First lot of kales may be drill
about end of March ; also seed beds of cabbage for spri
planting. Tilth forming operations for early sowings of sug
beet and mangolds, to be drilled about 7th April : where la
already ridged, horse hoe and saddle-back harrow to kill ann
weeds, re-form the ridges ; where grown on flat, light harrow
or discing according to need.

Grassland—Top dress mowing land, old and new, with 1½
cwt. per acre nitro chalk or sulphate of ammonia. Extermin
moles before dry weather comes, when moles begin to throw
hillocks in the growing grass. Harrow, stone-pick and r
Harrow and roll pastures. Not usually necessary to

nitrogen at this stage to sections to be grazed next after the early-bite field, but those grazed late by outwintering cattle may require help.

Cattle—Milk output now rises with more calvings. Usually spring calvers have lower lactation yield than autumn calvers, the decline in yield starting after peak at 3rd week, instead of remaining high for six or eight weeks: compare condition at time of calving and if necessary improve treatment of dry in-calf cows and heifers in late winter months. High mortality of March born calves may be due to poor nutrition, including lack of Vitamin A in diet of dam. Vaccination of young cattle for prevention of blackleg. Watch for signs of lice in both indoor and outdoor cattle, and for ringworm in calves. First dressings for warbles given now. Purchase of drape cows and other store cattle for summer fattening on grass.

Sheep—Lambing season. Twin lamb disease (pregnancy toxæmia) after hard weather in February; lamb dysentery; swayback. Feeding of ewes for milk production before grass comes.

Poultry—Egg output rises with lengthening daylight. February hatches now being hardened off for outdoor life.

General—Financial year ending. Prepare for animal stock-taking and valuation. Examine potato pits and mangold clamps and check sprouting. Old hedges now in best condition for pleaching (laying).

APRIL

Weather, etc.—April has long, sunny and many warm days but its nights are cold and frequently frosty. Although occasionally a wet month, April has a low average rainfall and low relative humidity; the soil surface usually presents the light colour of dry earth, and upturned clay forms clods. With the mean temperature rising from 44° F. to 48° F., vegetative growth accelerates and the countryside takes on its spring colours. Hedgerows, fruit bushes and some trees—horse chestnut, sycamore, larch—come into leaf; orchard trees come into blossom—damson, plum, cherry, pear and lastly apple; tulips and wallflowers bloom; the cuckoo and swallows arrive, and young rabbits are seen.

Arable—Complete the sowing of spring corn: in districts where frit fly usually attacks April sown oats, mixing with barley and heavier rate of seeding advisable. March sown cereals may require rolling. Sow grass and clover seeds where put in after the cereal has come up. Sow linseed and flax

Annual weeds appear in spring corn : when the cereal has not been underseeded, herbicides may be applied to destroy non-resistant weeds ; on lightish soils surface tillage may suffice ; acid spraying followed by harrowing where clovers not yet sown. Grazing of proud or forced wheat : soil must be dry enough to avoid poaching ; ensure even grazing over whole area ; do not over-graze or prolong the process ; top dress afterwards. Main sowings of sugar-beet, fodder beet and mangolds about 12th ; earliness important, but too early for situation may incur slow germination and bolters. Cleanest land for these crops. Main sowings of kales. Plant ox-cabbage. Finish planting potatoes, using sprouted seed. Horse-hoe and saddle-back harrow the earlies ; cover again if frost about. Heavy land to be bare-fallowed is given its first ploughing, unbroken furrow. Cleaning operations begin on lighter land for turnips.

Grassland—Good swards now growing fast. Avoid grazing mow-land and keep stock off pastures until there is a good bite, confining them to fields or sections reserved and prepared for first use, about 15th–21st according to season, etc.

Cattle—Prepare for grazing season. Cattle with good coats—open yarded—best able to withstand cold April nights on grass. Milking herd may begin to graze by day on early bite land (pasture, rye or Italian rye grass), lying in at night and receiving long fodder and concentrates—now low in protein to balance excess in young grass. Milk yields rise but fat content in morning's milk may be reduced. Young cattle and dry stock, to which poorer and more distant fields are assigned, may have to continue housed until they can be left out when released. Second dressing for warbles.

Sheep—Docking and castration of lambs. Avoid excitement likely to cause bleeding. Reduce protein in concentrates with growth of grass. Suckling ewes may need drinking water.

Orchard—Pre-blossom spraying for prevention of capsid.

MAY

Weather, etc.—The month of flowers—cherry, pear, apple, horse chestnut, azalea, rhododendron, laburnum, lilac, and hawthorn ; tulip, wallflower and stocks ; daisy, dandelion, and buttercup ; and among cultivated crops—field beans, early peas and seed crops of brassicas. With mean temperature rising from 50° F. in the first week to 55° F. in the last, vegetative growth accelerates. Oak, ash, beech, Spanish chestnut and walnut come into leaf ; rye, Italian rye grass and foxtail shoot ; winter wheat grows up to form a canopy and by the end of the month spring corn covers the ground. Sugar beet, mangolds and early sown kale form green lines and first-early potatoes are up. Pastures afford a full bite. Young rooks begin to leave the nest about the 12th. Days are long and bright sunshine averages five to six hours per day. Yet it is not summer: there are usually cold east winds and during the first fortnight ground frosts occur on three to five nights in the Midlands. May has a little more rain than April, but its average humidity is the lowest of any of the twelve months, so that upturned soil dries quickly.

Arable—Complete the application of nitrates to cereals; pull docks and thistles; patch partial failures with buckwheat. Ensile rye just before shooting about 7th to 10th, cutting with self binder when not wet: if mixed with Italian rye grass, top-dress immediately for 2nd cut in July. Italian rye grass and broad red clover mixtures are ready for ensiling about a week later. Finish sowing sugar beet and mangolds; if soil rather dry sow deeper and roll heavily. In northern and upland districts swedes may be sown; 10 lb. per acre borax prevents brown heart. Swedes and kales require beetle dust when sown in May. Apply protective dust round base of cabbages against root maggot fly. Sow maize, with precautions against rooks. Horse hoe between rows of root crops and start singling the earliest brairds; saddle-back harrow ridges of potatoes not yet up. Plough headlands and drill with kale. Continue cleaning operations on land for turnips. Reverse the furrow slices on bare-fallow.

Pastures—Abundant, leafy keep; but restrict area grazed in May to what can be bared off once in the month, mowing the rest for silage. Four or five sections, each about 1/6 acre per cow; graze down each section in turn, then rest it till next round; if watering facilities allow, close fold. One or two sections may be available for silage about 21st, then top dressed and rested for grazing in the July rota.

Meadows—Haymaking begins about the end of May in early districts. Sulphate of ammonia may be applied fourteen days before mowing to increase protein content of hay and stimulate aftermath.

Cattle—All now lying out at night except calves: those born before Christmas should be brought in at night and fed with hay for a fortnight. Watch for cases of scour and bloat on young swards and observe udders of cows recently dried off, which sometimes resume secretion. Older cows not seen in season during the winter may take service in May to calve in February, which is also a good month for spring calving of heifers. Supplementary rations for cows should counter-balance high protein and low fibre content of young grass. Continue warble dressing.

Sheep—Castration and docking of late lambs ; vaccination against pulpy kidney ; begin worming. Keep ewes clean. Heavily woolled sheep may get on their backs. Sheep washing a week or two before shearing near end of month.

Poultry—Egg production now begins to fall. Remove broodies from nest boxes and feed well in broody cages. Chickens now in field arks : keep the grass short.

Machinery—Check over mowers and other hay machinery in readiness for busy season next month. Corn and other seed drills and fertiliser distributors properly stored till required in autumn. Painting. Order plough shares.

Odd jobs—Whitewash cowsheds. Paint gates. Creosote wooden houses and tar felts. Tidy up stackyard. Clean out calf boxes. Spraying of apples against sawfly.

JUNE

Weather, etc.—With mean temperatures rising from 56° F. in the first week to 59° F. in the last, ground frosts having ceased and the soil still moist, vegetative growth is now at its maximum. Bright sunshine averages six hours per day and daylight extends over 16 hours. June rainfall is on the average moderate or low but occasionally heavy and hindering. June is the flowering time of most herbaceous plants—grasses, cereals, legumes ; charlock and other weeds in spring corn ; sorrel, dog daisy and pig nut in the meadows ; and lupins and delphiniums in the garden. The root crops now begin to complete the green pattern of the fields, though this may be broken by the stubbles of early sown leas ; and by the end of the month all the cereals are in full ear and recognisable at a distance by their distinctive shades of green.

Arable—Sowings include common turnips, swedes south o the Trent, rape for October folding, grass and clover seeds no under cereal cover. There may be late plantings of cabbage cauliflower, etc. The main job, however, is hoeing and singlin root crops ; and on the forwardness of this work before hay making begins depends the success and cleanliness of the crops If necessary leave kales unsingled. Apply nitrate top dressing to green crops. Charlock in full flower may be sprayed wit acid or copper salts. Ensile cereal-legume mixtures about mid June or before the cereals are fully shot. Early potatoes now ready for lifting but growing rapidly. Crop pests apparent i June are mangold fly, pigmy beetle, spring tails and cut worm on sugar beet ; root maggot in cabbages ; frit fly in oats, an loose smut, take all, eye spot and rust in wheat.

Grassland—June hay if well harvested is higher in prote and lower in fibre than forage cut more mature, but such herba is more sappy and susceptible to weather damage during drying. In unsettled weather make silage ; in settled weather give priority to securing the fields with the heaviest and most leafy or clovery herbage ; more liberty can be taken with stands composed mainly of rye grass or cocksfoot. Cut when dry ; move swaths soon after tractor mowing, usually being much rolled down by wheels. If not pick-up baled, may be advantageous to sweep to round " pikes " of 10–25 cwt., based on three to six bales of straw spaced to admit air underneath : shortens time between mowing and securing. Arrange " pikes " in groups for convenience in stationary baling ; bale after drying out, about 10 days. Watch density of bales. Stacking. Salting of hay.

Cattle—Strong calves now lie out at night on clean new grass. Bulling for March calving. Observe cattle with persistent winter coats—a sign of unthriftiness or cobalt deficiency. Milk yields begin to decline but fat content of mornings milk still requires supervision. With higher temperatures keeping quality requires extra care : fore-milk and sterilisation of apparatus.

Sheep—Shearing. Dipping. Maggoting. Worming of lambs. Sale of early lambs and fat ewes. Foot-rot bath.

JULY

Weather, etc.—July is the hottest month of the year, with mean temperature of 60° F. in the Midlands and an ordinary maximum day reading of 70° F. : occasionally the thermometer reaches 80° F. July rainfall has a rather high average, though it varies from 3 in. down to 1 in. in different years. A wet July freshens the pastures and June-mown meadows but hinders hay-making, stimulates the green crops and their weeds and, especially when there are thunderstorms, causes cereals to lodge. The main crop potatoes, having flowered, meet across the rows ; the other green crops grow rapidly and begin to cover the ground, and by the end of the month rye and winter oats become yellow ripe. In early districts or in early seasons wheat harvest may begin. Poppies, thistles and docks show in some corn fields, uncut ragwort and thistles flower in pastures ; bramble, foxglove and willow herb flower in hedgerows.

Arable—Endeavour to finish inter-row hoeing of green crops before such work would damage the root fibres which spread across the spaces between the rows. Long weeds may have to be pulled out. Earth-up late potatoes with moist mould to prevent greening of tubers. About the 15th give first spraying to protect against blight. Lifting of earlies and second earlies continues. Look out for appearance of black aphis in sugar beet. Land cleared of silage crops in June, having been ploughed twice, may, if clean enough, be fertilised and drilled with rape for cow folding in October : use beetle dust to prevent turnip fly. Mustard, buckwheat, rye and Italian rye grass are other catch crops suitable for July sowings. Lea stubbles intended to be bastard fallowed for wheat may be ploughed when moist enough to furrow depth : may bake hard if opportunity missed.

Grassland—Most pastures now bare and aftermaths not yet ready ; of great value, therefore, are fields or sections reserved and treated to bridge this " July gap "—pastures grazed in May, top dressed, rested in June ; aftermaths of grass cut for silage in May ; early-sown direct re-seedings. July is still the chief haymaking month, little being cut in upland and northern districts in June. Nitrogenous top dressings may be given to hay stubbles to increase growth of aftermath, some of which may be ensiled in August or September ; and to pastures intended for re-stocking in autumn.

Cattle—Milk yields drop steeply—end of lactation, heat, lack of shade, flies, warble fly, shortage of grass, white clover in flower. Cows now dry for autumn calving require special and frequent udder inspection for 'summer' mastitis caused by Corynebacterium. Cases treated for other forms of mastitis during lactation should be re-examined and perhaps re-injected with a view to complete cure. Heifers shortly due to calve may be brought in with the milking herd and fed in their stalls. Calves out of doors must be watched for signs of husk and if necessary wormed. Keep fences sound and keep bulls indoors or tethered near homestead.

Sheep—Weaning and worming of lambs. Maggoting. Marking of ewes intended to be culled.

Poultry—Complete culling or marking of two-year-olds for sale before moulting. Watch for coccidiosis in chickens after rains.

AUGUST

Weather, etc.—The middle month of the summer quarter more like July than September but sunset earlier and average rainfall higher, especially in western districts. Meadows now carry green aftermath and burnt up pastures recover ; Agrosti swards bear red culms ; corn fields yellow ripe or cut ; heathe in bloom.

Arable—Winter varieties of rye, barley and oats usually ripe by end of July or early in August. Average dates for starting t cut (self-binder) other cereals in Midlands are : oats August 8th wheat 11th, barley 18th : oats and wheat when yellow ripe an kernel breaks clean over thumb nail ; barley white ripe. Early and late ripening varieties in each species. Oats that shed or lodge are cut on early side, also certain wheats that readily shatter. Crops to be combine-harvested require 10 days longer. Peas for grain cut or pulled when most of pods are brown but not opening ; beans when hilum of seed is black though straw still green. Normal duration in stook : oats 14 days, wheat 10, barley 7, all depending on weather, ripeness of straw and herbage in butts of sheaves. Beans three or more weeks. Peas 7–10 days ; best in tripods. Late potatoes receive second or third spraying ; seed crops sometimes acid-sprayed to kill tops. Kales may require further top dressing of nitrates. Seeding stalks of fat hen, red shank and knot grass in root crops should be pulled and carried off. Ploughing of rotation leys for wheat proceeds when land moist enough. Grassy swards not ploughed before September not good for wheat—frit fly, re-growth of grass ; preferred left for spring oats in northern districts. Stubble cultivations : essential where winter cereals grown in succession; success depends on early start after reaping, also on weather. Second crop " seeds " mown for hay or ensilage according to weather conditions ; often best to ensile. Lucerne should be allowed to grow ungrazed after the (third) August cutting until cut back by frost. August sowings : suitable time for all kinds of grass and clover, e.g., pasture seeds after fallow or early potatoes or old turf ploughed for direct reseeding ; patching of weak takes of maiden " seeds": cabbages for spring planting ; mustard and buckwheat for autumn feed or green manure; rape for late autumn or spring feed ; crimson clover ; rye and Italian rye grass for early spring use ; use fertilisers. Order seeds for autumn sowing—wheat, beans, etc.

Grassland—Mow rough parts of pastures ; complete cutting or re-cutting of thistles. Top dress with nitrogen and rest fields reserved for October–November grazing. Ensile surplus aftermaths. Meadows may be manured by top dressing and grazing the herbage produced.

Cattle—Generally as for July but more cows dry and subject to " August bag " and more heifers calving. Special care and patience required with these. Avoid hoven or bloat by gradual introduction when grazing clovery aftermaths. Reduce fly infestation of cowsheds.

Sheep—Newly weaned lambs require new swards, doing badly on worm-infested pastures : maiden seeds and a run on unploughed stubbles. Cull ewes. Attend to feet. Continue watch for maggots.

Poultry—Prepare winter houses for pullets and transfer before they begin laying. Feed moderately to avoid losses at this stage. Use of hens on stubbles to control wild oats.

SEPTEMBER

Weather, etc.—The last month of summer with some hot sunny days and no night frosts until near the end, when signs of autumn appear—the earlier sunset, cool and often misty evenings. heavy morning dews, autumn tints about the trees, the hedgerow berries, and the behaviour of swallows and starlings Normally a dry month with less than 2 in. of rain in the eastern side of England and sometimes baking the leys and stubbles too hard for ploughing but occasionally so wet as to hinder and damage corn in stook in the later districts. In a favourable season one of the busiest months in the farmer's year.

Arable—Corn cutting continues in the northern counties carting or the completion of combine-harvesting elsewhere Thatch stacks intended for later thrashing. Thresh for autum seed corn after the time, usually three weeks, required for conditioning. Obtain any new seed required. Proud clover should be grazed back to prevent flowering and winter loss Weak 'plants' may be due to sowing too late—or to over shading by the cereal. Partial failures may be patched wit rye-grass and alsike. Stubbles intended for autumn sowing wit a second corn crop (more common in dry than in humid districts usually require shallow cleaning operations before ploughing Docks, however, must be forked out and hand picked. Clove leys not containing grasses require only once ploughing for whea but grassy mixtures which are more difficult to kill and ma harbour frit maggots, should be skimmed, worked and reploughed, or left for spring oats. Lift second early potatoe Spray to kill tops of late potatoes, early if blight appears, late in the month if healthy. Begin lifting sugar beet if require though growth continues in October. Sow rye or rye and Italia rye-grass for March–April grazing or early ensilage. After bar fallow or early potatoes, wheat may be sown before the end September, provided the soil is not too dry and if seed rate reduced.

Grassland—Ensile spare aftermaths or second crops " seeds." Fields grazed down in August, top dressed and reste in September will usually provide valuable grazing for la autumn use. Finish mowing thistles and rough parts pastures. Harrow to spread droppings. Ploughed up pastu may be re-seeded in September. Clean out waterings and pon (water born diseases).

Machinery—Clean and store reaping machinery. Prepa for busy ploughing season. Check over corn drills a potato lifting equipment.

Cattle—Prepare dry in-calf cows and in-calf heifers for calving, bringing them in at milking time to receive concentrates and to become accustomed to tying in stalls. Continue look-out for dry-udder mastitis. Re-examine udders of all dry cows. Re-select heifers for autumn bulling and, if necessary, vaccinate with S.19. Autumn vaccination of yearlings for blackleg if advised. Look out for husk in calves, which should now come indoors at night and go on to virgin sward by day. Autumn sales of store cattle.

Sheep—Complete selection of ewes and " flush " for October tupping. Autumn dipping. Worm treatment of hoggs if scouring. Make food changes gradually. Vaccination for local diseases—braxy, louping ill and black disease. Sales of store sheep.

Pigs—March litters now nearing bacon weights. September litters arrive. Feed sow well to promote milk yield and maintain condition necessary for re-service in November.

Poultry—Complete sale of two-year-olds and culling of year-old hens. Prepare houses for reception of pullets, which are now fed gradually increasing rations to bring them into lay.

OCTOBER

Weather, etc.—The first month of autumn, marked by the yellowing of the leaves of hardwood and orchard trees, the withered and brown potato tops and the change from yellow stubbles to newly ploughed earth. With the continuation of Summer Time daylight extends beyond the afternoon working hours, but little can be done out of doors in the evenings. It is now dark in the mornings when the cows are brought home for milking. The soil, however, is still warm enough for the quick germination of cereal grain and for some growth of grass, cabbage, kale, swedes, mangolds and sugar beet, but night frosts begin after about the 21st. October is usually a month of heavy rainfall, but the effect of the rain depends upon the weather of September. Two wet months in succession handicap operations on heavy land.

Arable—Finish lifting potatoes. Protect heaps against frost and rain whilst allowing to dry out and cool. Do not trust blighted crops to keep. Some sacrifice of yield of sugar beet may be offset by lifting under favourable soil conditions and by earlier sowing of the wheat that follows. Mangold lifting begins about the 15th, according to area, to finish about the 31st ; but if the weather is warm, leave the roots to cool in small heaps in the field covered with tops.

Cut and cart or fold marrow stem kale and ox cabbage, the cabbage first if too forward. May be fed alternately with sugar beet tops. Disposal of surplus sugar beet tops.

The chief autumn-sowing month. Order of sowing :—(1) wheat on bare-fallow which may become sodden and unsowable if delayed ; (2) rye or rye and rye-grass mixtures for early bite or ensiling ; (3) winter beans, winter oats and winter barley, all of which are less hardy than wheat ; (4) wheat after early ploughed leas and cleaner stubbles ; and (5) wheat after potatoes, mangolds and sugar beet. Combine-drill with 1–2 cwt. of superphosphate when conditions allow of drilling. Sometimes it is possible and advisable to sow broadcast and cover with disc harrow rather than risk delay of waiting for drilling conditions.

Luxuriant maiden seeds may continue to be grazed, but avoid too severe eating down, poaching and grazing in frost. Seed failures may be ploughed up and re-sown with Italian rye-grass for hay or with rye and Italian for silage followed by hay.

Grassland—Pastures intended for early spring grazing, having been grazed down in September, should be shut up by mid-October, harrowed and rolled, and rested until spring.

Orchard—Finish picking apples. Grease band the trees. Cut out old canes of raspberries and tie up the new.

Cattle—Winter coats now growing. Clip flanks, etc., of milkers. Keep newly calved cows and heifers indoors at night and feed with cabbage and hay, plus concentrates for a rise in yield. All go out in the morning to kale, cabbage or beet tops and receive oat straw as fodder while a bite of grass lasts. Dry in-calf cows and heifers receive green food and oat straw on the pastures in the morning after indoor rations with the milkers. Bulling heifers are kept in growing condition. Yearlings still lie out, but calves under nine months are yarded day and night.

Sheep—The lowland ewe flock is prepared for tupping, about the middle of the month by good feeding, attention to feet, winter dipping if not done in September, and by vaccination for lamb dysentry where necessary. Forward hoggs intended for grading before Christmas receive trough food.

Work Horses—Special care is required to avoid " founder " and digestive troubles when horses begin to lie in at night or when work is suspended after beginning to receive heavy rations. New corn is not a safe food for full feeding.

Poultry—Pullets in lay are liable to lose condition and fall into a neck moult about the end of October unless fed well Artificial lighting assists.

General—Survey food supplies and calculate rations for winter feeding. Review the results of the summer half-year

NOVEMBER

Weather, etc.—Generally a wet and stormy month with many fogs and night frosts keen enough to damage mangolds lying after pulling unless covered with tops. Mornings are dark until after 7.0 a.m. and daylight fails about 4.30 p.m., so that special thought has to be given to keep the teams and tractors in motion whenever the soil permits of land work. The soil rarely looks dry from now until February or March. Plant growth gradually slows down to dormancy with fall in mean temperature to about 41° F. after the third week. Wheat sown about mid-November may not show above ground until after mid-December unless unusually mild weather prevails.

Arable—Finish lifting potatoes by the 7th ; complete earthing up of the clamps by the 20th, changing the straw if wet. Clamps showing signs of bad keeping should not be earthed up but sold forthwith. Mangold lifting should be completed by the 10th. Clamps of mangolds should be protected with a thick layer of rough forage, not soiled up ; but the roof should be sloped to turn water, that from melting snow being likely to conduct frost if allowed to percolate. Lifting of sugar beet may continue to the 30th, roots awaiting dispatch to the factory being carefully piled with the cut ends outwards and covered with straw. Swedes are lifted and stored.

On light, well-drained land wheat may be sown after clean root crops without ploughing ; but on heavier soils, which tend to run together after rain, a shallow ploughing is desirable to provide a coarser surface. Drill or sow immediately after the plough, before rain turns the soil sticky. It may be better to broadcast the seed and harrow in rather than wait indefinitely for conditions suitable for the drill to work. Increase seed rate to three bushels to allow for bird damage ; but drill shallow to promote early emergence, and protect from birds with lines of black cotton. Superphosphate encourages wheat seedlings. Try to finish sowing by 15th on heavy land. Rich light land may be sown later.

Winter ploughing of stubbles for next year's root crops proceeds as men and equipment are released from root lifting and wheat sowing. Clean stubbles that have been yard manured are given a first furrow of 4 in.-5 in., not to bury the dung too deeply ; dirty, unmanured stubbles receive a deep 8 in.-9 in. furrow, to kill weeds, manure being covered half depth at a subsequent ploughing. Clover root for potatoes is treated like clean stubble. Winter ridging is advantageous on heavy soils in humid districts.

Cattle—Some of the strongest heifers are bulled about mid-November for calving at the end of August or beginning of

September. Those calving a month later produce a greater part of their lactation yield when prices are higher, but heifers are less easily "caught" in the colder weather of December and January, especially when lying out. Younger heifers are better wintered in open yards, or yarded at night, well-fed and bulled later.

Begin night-housing milkers after a dry day ; keep sheds cool to encourage growth of winter coats but clip flanks and buttocks ; provide enough litter for cleanliness and prevention of injury from hard floors. Milk at nearly equal intervals ; deep milkers may need a third milking. If water bowls not provided, turn out to trough twice a day.

Sheep—Take away rams from lowland flocks. Tupping time for hill flocks. Attend to fences before wandering habit develops ; eradicate blackberry bushes in which wool may become entangled.

Poultry—Continue liberal feeding of laying pullets ; take precautions to avoid dirty eggs. Second year hens for breeding should still be resting and on moderate diet. Geese for Christmas market now begin to receive fattening rations, which may include boiled potatoes.

Yard Manure—Yard manure disposal now beomes a problem with the cows housed night and day. Daily carting away i the ideal. When there is no more clean stubble to which i can be applied before ploughing for roots, or when the land i too soft to carry the carts, it may be stacked near the ploughe land for later application, perhaps during frost. Maiden seed also pay for dung and, on farms with more meadow tha arable land, dunging of mow meadows may begin.

DECEMBER

Weather, etc.—The month with the shortest days and th least sunshine, one of the wettest but not so cold as January usually calm. Deciduous trees now bare except for the yello leaves lingering on oak, beech and hornbeam. Frequen morning frosts but little thick ice, and snow does not usuall lie long. Mean temperature 40° F. or under (milder in S.W and W. districts) hence plant growth is limited to the effec of any mild weather and bright sunshine on rye grasses, ry and wheat. In such periods drill rows of seedling whe suddenly appear green after the seed has lain in the groun several weeks.

Arable—Finish lifting sugar beet, fodder beet and swede Examine potato clamps for keeping. Wheat sowing ma continue on well drained soils when conditions permit and is favoured on rich fen soils where earlier sowing produces too much straw. Late sowings require special protection, first against rooks and pigeons and after brairding against larks and starlings. Seed sown late in December, however, may come up at the same time as that sown a month earlier if the weather has been cold.

Continue stubble ploughing. Deep covering now kills much of the grassy weed material on heavy soils ; on light land stirring it on the surface is recommended. Where heavy land is slow to dry out for working in April, winter ridging in December, splitting over the manure in January or February, reduces spring operations to superficial workings on the ridges.

Grassland—Application of lime, phosphates, potash and to mowing land liquid or yard manure. Laceration of old grass swards, followed by phosphatic dressings and rolling. Destroy ant and mole hills. Flood water meadows.

Cattle—Continue full rations of kale or cabbage to the dairy herd but with precautions in frosty weather. Hay now instead of straw as the long fodder ; two feeds better than one large supply. Serve September–October calvers.

Yearlings may stay out of doors until Christmas, if supplied with kale or cabbage and fodder, then bring into yards, dividing into suitable groups. Bulling heifers now require more liberal feeding, especially if lying out, to avoid failure to conceive.

Sheep—In-lamb ewes to be kept in steadily growing condition and may now require a rack of hay and ½-lb. crushed oats. Watch for symptoms of liver fluke and worms.

Other work—Threshing. Marketing potatoes, boxing seed. Hedge laying. Ditching and draining. Winter spraying of apple trees. Planting of fruit trees, bushes and quicks.

FARM ACCOUNTS

Book-keeping covers a record of all the cash passing in and out of the farm. It is a means of determining whether or not a farm is profitable whilst in its more advanced stages it provides the cost of production of the various crops and classes of animals.

PROFIT—" Profit " is the excess of the sum received for an article over the cost of production. To arrive at profit would be simple if a farmer merely bought and sold, but he does more than this. He actually produces an article ; in the case of crops, from the very earliest stages of ploughing and seeding until they are harvested, and in the case of live stock from the time the animal is born. It is therefore impossible to arrive at the profit on a farm by merely considering purchases and sales. There must be taken into account the values which have accumulated at the end of the farm year and which are not represented by cash, such as valuations of herds, flocks, crops ingathered and unsold, cultivations, etc.

COMMENCEMENT OF ACCOUNTS—As a rule, an Annual Profit and Loss Account and Balance Sheet are prepared from the records of farm transactions at the end of the farm year. That year can close at any suitable date. Often the year agrees with the term dates applicable to the country. For example, a suitable period in England would be the year ending in September and in Scotland the year ending in May, or any chosen term date ; or the date may be arranged according to the date of entry to the farm. It is suggested that the Autumn term is most suitable because by that time the crop has been harvested and there are no cultivations, so that the question of the Inventory and Valuation becomes a simple one. The Books required for keeping the records are two, namely :—

1. Cash Book, and
2. A record of the Annual Inventory and Valuation.

CASH BOOK—This Book is very simple to keep and a farmer's Cash Book can be procured at any mercantile stationers or from some of the farming societies. The Table shown facing page 600 is an example of the National Farmers' Union Cash Book :—

No one should be deterred by the appearance of this Cash Book. Careful study will show that it is simple to keep and it is used in practice by a large number of farmers.

Certain entries have been shown in the above examples to make it quite clear how the Book should be written up. It must contain a record of all money received and all money paid out, whether or not these sums represent farm or private transactions, cash payments or payments by cheque. It must be written up regularly and, as farmers' transactions are few in number, it can be written up once a week.

In the case of small petty transactions which occur on a farm at irregular intervals, a note of these should be kept in a small Pass Book and they should be entered in the Cash Book in one sum at the end of each month as " Sundry Expenses."

CONTRA ACCOUNTS—Frequently transactions are settled by contra, i.e. in the case of a farmer who owes money to a supplier who, in turn, owes money for goods supplied to him, the items are recorded in the Cash Book as if the customer paid the farmer the sum he was owing and the farmer paid to the customer the sum due. For example, " A.B.," a farmer, owe " C.D.," a grocer, £20 and in return " C.D." is owing for the supply of Eggs £2 10s. The entry should be recorded as follows

On the Receipts side of the Cash Book :
" C.D." Egg Account £2 10

On the Payments side of the Cash Book :
" C.D." Groceries Account £20 0

Only the sum of £17 10s. would change hands, but the transaction would be recorded in full.

Care should be taken to give full details of the nature of eac transaction. The absence of details makes it difficult to prepar correct Accounts at the end of the year. The Inland Revenu scrutinise accounts and frequently questions arise regardin Repairs, Renewals and Sundry Expenses, etc. These can on be answered if the full details appear in the Cash Book. Numbe and description of live stock bought and sold should be entere in the details column, and particulars of implements sold acquired noted. Car registration numbers should be recorde for example :—

Austin Saloon, 1949, 12 H.P.—CHS. 600.

ACCOUNTS PAYABLE—When goods are delivered by supplier they are usually accompanied by an invoice giving t details and the value. Subsequently an account is rendered the supplier which may embrace a number of invoices bringi out a monthly or period total for payment. Care should taken to handle these documents in the following way :—

Invoices sent by a supplier should be kept on a two-pin file which can be obtained from any stationer, and the file marked "Unpaid Accounts." These invoices should be kept in alphabetical order, each firm's invoices being together. When an account is rendered for payment the invoices should be taken off this file, attached to the account rendered and paid. This document now becomes a receipt and this receipt should be placed on another two-pin file marked "Accounts Paid." In this file the account should appear in the order of the entry in the Cash Book, i.e. date order, and it is advisable to number the account in blue pencil with the same number as appears opposite the item in the Cash Book. By following this system it is easy, at any time, to ascertain what Accounts are due and unpaid at the end of the financial year.

ACCOUNTS RECEIVABLE—These are few in number because, as a rule, a farmer's stock is sold towards the end of the year in large quantities and there is not a large number of small transactions.

Accordingly, a record of all goods which have been sold and not paid for can easily be kept in a small notebook. When the cash is received the items can be marked off in the notebook as paid and the amount received entered in the Cash Book. As many transactions of the farm are for cash, such as market transactions, these are entered in the Cash Book at the time they occur and this is the only record made, the Sale Note of the Mart or other statement of the transaction, such as the Ministry of Food's voucher, being kept separately in order to explain the item itself.

ANNUAL INVENTORY—This is important. An Inventory must be made each year of all live stock, grain, cultivations, loose tools and implements on the farm. The first Inventory is at Ingoing and this can be compiled readily from the documents prepared at the time of Ingoing showing the stock taken over and paid for. This stock includes the value of cultivations and other matters. If there is no Ingoing cost, then there is no Inventory at the beginning and all purchases being made during the year to stock the farm are recorded in the Cash Book in the usual manner. An Inventory, however, must be made at the end of the year, at the date which has been fixed, as already suggested, as the most suitable date to complete the farm year. It consists of three sections :—

1. Stock on hand.
2. Accounts due to the farm.
3. Accounts due by the farm.

On taking the first Inventory, the following information should be recorded :—

1. **Stock on hand**—(*a*) Live stock—distinguishing between the various classes and showing the values in each case.

(*b*) Grain, feeding stuffs, sundry stores, and cultivations.

(*c*) Loose plant : These need not be listed but a careful estimate should be made of their value and only the total stated in the Inventory.

(*d*) **Implements**—This list covers all the implements on the farm, with a description of each and registration numbers where these apply, and it states, if possible, when the implement was bought and its cost at date of purchase (if known). If the latter figure is not known, the estimated value at the date of stocktaking should be shown opposite each item.

(NOTE—Loose plant and Implements only require to be recorded once, either in the opening Inventory or, where this does not apply, the first Inventory made at the end of the first farming year. They do not require to be taken annually.)

2. **Accounts due to the Farm**—These can be ascertained from the notebook already referred to and should include sums due for Subsidies, Drainage Grants, etc.

3. **Accounts due by the Farm**—A list of these is taken from the " Unpaid Accounts " file and there may require to be estimated certain amounts due to persons who do not send invoices, such as blacksmith, joiner and other tradesmen.

EXAMPLES USED IN ACCOUNTS (being the Opening and the Closing Inventories showing the classes of Stock on Hand, the accounts owing by the farm and the accounts owing to the farm) :—

TABLE 195—OPENING AND CLOSING INVENTORIES

AS AT 31st MARCH 1952

	£	
Live Stock		
CATTLE		
28 Breeding cattle at £25	700	
68 Dairy cows at £45	3,060	
2 Bulls at £60	120	
39 2-year-old heifers at £50	1,950	
24 1-year-old heifers at £30	720	
34 Calves, heifers at £18	612	
		7,16
SHEEP		
24 Breeding ewes at £12	288	
2 Rams at £40	80	
6 Ewe hoggs at £7	42	
18 Cast ewes at £6	108	
		51

	£	£
HORSES		
1 Mare at £60	60	
		60
POULTRY		
30 Hens at £1	30	
		30
GRAIN, ETC.		
400 cwt. Oats (unthreshed) at 20s. p.c.	400	
10 tons wheat straw at £3 p.t.	30	
10 tons barley straw at £3 p.t.	30	
10 tons oat straw at £4 p.t.	40	
20 tons rotation seeds at £9 p.t.	180	
		680
MISCELLANEOUS		
Farmyard manure, estimated at		250
Cultivations.		
26 acres wheat, £10 p. ac.	260	
50 acres barley, £10 p. ac.	500	
58 acres oats, £10 p. ac.	580	
27 acres potatoes, £10 p. ac.	270	
29 acres turnips, £5 p. ac.	145	
70 acres pasture, £4 p. ac.	280	
		2,035
TOOLS		200
		£10,935

PLANT, ETC.	
Fixed plant (i.e., machinery under cover)...	700
Implements	1,800
Reapers and binders	200
Motor cars and vans	920
Tractors	800
	£4,420

SUNDRY CREDITORS	
S.A.I.—Feeding stuffs	210
S.A.I.—Manure	100
Seeds	20
Wages	157
Repairs	93
General expenses	97
	£677

SUNDRY DEBTORS	
M.M.B.—March milk	698
Potatoes, Ltd.—Potatoes	913
	£1,611

AS AT 31st MARCH, 1953.

	£	£
Live Stock		
CATTLE		
25 Breeding cattle at £25	625	
65 Dairy cows at £45	2,925	
2 Bulls at £60	120	
45 2-year-old heifers at £50	2,250	
30 1-year-old heifers at £30	900	
28 Calves, heifers, at £18	504	7,324
SHEEP		
29 Breeding ewes at £12	348	
3 Rams at £40	120	
20 Ewe hoggs at £7	140	
11 Cast ewes at £8	88	696
HORSES		
1 Mare at £60	60	
1 Filly (cost) at £50	50	110
POULTRY		
40 Hens at £1	40	4
GRAIN, ETC.		
400 cwt. barley at 28s. p.c.	560	
300 cwt. oats (unthreshed) at 20s. p.c.	300	
6 tons wheat straw at £3 p.t.	18	
9 tons barley straw, at £3 p.t.	27	
9 tons oat straw at £4 p.t.	36	
20 tons rotation seeds at £9 p.t.	180	
20 tons potatoes at £11 p.t.	220	1,34
MISCELLANEOUS		
Farmyard manure, estimated at		25
CULTIVATIONS		
27 acres wheat, £10 p. ac.	270	
43 acres barley, £10 p. ac.	430	
43 acres oats, £10 p. ac.	430	
24 acres potatoes, £10 p. ac.	240	
23 acres turnips, £5 p. ac.	115	
100 acres pasture, £4 p. ac.	400	1,8
TOOLS		2
		£12,8

(At this date no valuation of plant need be made)

SUNDRY CREDITORS	
S.A.I.—Feeding stuffs	110
S.A.I.—Manure	80
Seeds	40
Wages	143
Repairs	46
General Expenses	58
	£457

SUNDRY DEBTORS	
M.M.B.—March milk	886
Potatoes, Ltd.—Potatoes	722
D. of A.—Lime subsidy	92
	£1,700

HOW TO VALUE STOCK—The Inventory should be made by the farmer himself on the last day of the farming year when the stock on hand are recorded and classified under the appropriate headings shown above. The principle followed in putting a money value on the various articles is to take as a basis the cost or market price, whichever is the lower. In the case of purchased goods the cost is easily ascertained, but in the case of goods produced on the farm the cost is not so easy to estimate. There may be a large number of home bred live stock, also grain, feeding stuffs, and, in particular, cultivations, i.e. crops in the process of growing and not yet harvested. So far as possible a close estimate should be made as to the cost but, in case of any difficulty, it is reasonable to include home produced animals at market value less 25 per cent. The following extract from the document covering the arrangement agreed between the Inland Revenue and the Farmers' Unions is of interest :—

> "In the case of live stock bred on the farm if it is not possible to ascertain actual cost, no objection will be raised (by the Inland Revenue Department) to the acceptance of, as cost valuation, market price less 15 per cent. (this is now 25 per cent.), this basis however to apply both for the opening and closing of the year of account by reference to the market price at the opening and closing dates respectively."

In the case of purchased animals, the cost price should be the price paid with some additional figure to cover the estimated cost of the keep of the animal on the farm from date of purchase to the date of the Inventory.

This additional cost however only applies in the case of immature animals, e.g. cows will appear as a fixed value from their first lactation.

BANK ACCOUNT—This is a most important part of the farm financial scheme and if used properly by the farmer helps greatly in preparing the Annual Accounts. Where possible accounts over £1 should be paid by cheque and if cash is required to meet farm expenses a round figure of, say, £10 should be drawn from the bank for this purpose. When this money is expended it should be recorded as already explained When cash for personal purposes is required, a round figure should be drawn of, say, £20 and entered in the Cash Book as “ Personal Drawings £20.” Any household accounts, however such as grocer, butcher, tailor, etc., paid out of the farm Bank Account by cheque should be entered under the name of the person to whom the sum has been paid and the entry placed in the details column (column 5) and the word “ Private ” entered in column 3. This amount will, in due course, be extended to the last column in the Cash Book (column 13).

If an account is rendered by a supplier such as for example :—

“ John Hunter ... ... £58 10 0 ”

which covers feeding stuffs £25 and manures £33 10s., the account should be analysed at the time of payment and a note made on the account of the analysis as above. This enables the account, when entered in the Cash Book, to be allocated to it appropriate columns. Care should be taken to enter on the cheque counterfoil the name of the person to whom payable an the nature of the payment, whether for feeding stuffs, cattle, etc If the purchase is live stock, the number should be stated. Th applies to all purchases.

A “ Pay-in Slip Book ” should be obtained from the bank i which to record all moneys paid in. These sums should agre with the entries in the Cash Book and will form a further check All cheques received at the farm should be lodged in the ban with other receipts after recording the details in the Pay-in Sli counterfoil. Many farmers pay a cheque or cheques into th bank only to a certain amount, obtaining cash for the balance This is a bad practice and leads to endless trouble at the end o the year. The maxim to follow is to lodge all cash received i the bank without deduction and make all payments over £1 b cheque except for wages, or comparable payments.

WAGES—A Wages Book is essential in which to record th name of the employee, the nature of the work, the date wh employment commenced and the wage. Information concerni P.A.Y.E. is best obtained from the Inland Revenue offices. there are several employees and the wages are paid weekly

Wages Book should be acquired from a mercantile stationer and the weekly wages recorded therein, the total only being entered in the Cash Book. When wages are paid quarterly they should appear in detail in the Cash Book each quarter, no Wages Book being necessary.

PREPARATION OF PROFIT AND LOSS ACCOUNT—At the end of the year a completely detailed Cash Book and appropriate Inventories will be available. After taking into account the cash drawn from and lodged in the bank the receipts side of the Cash Book should exactly equal the payments side. If not there may be cash on hand, i.e., cash not yet lodged in bank, or some entries may have been omitted from the Cash Book and this should be checked with the cheque counterfoils and the pay-in slips. Income and expenditure must agree and hence the recommendation that all receipts and payments, whether private or otherwise, be recorded in the Cash Book. If this has been accurately kept the following will be the appearance of the abstract :—

ABSTRACT OF CASH TRANSACTIONS

Cash Reconciliation

RECEIPTS

	£	£	£
Cash on hand at 31st March, 1952			86
*Cash Sales & Receipts—			
97 Cattle	1,654		
Milk	7,678		
Potatoes	1,722		
Oats	1,258		
50 Sheep	488		
		12,800	
Subsidies—			
Ploughing	85		
Potato	250		
Lime	110		
		445	
Shooting Rent		10	
Private Receipts—			
Deposit Receipt uplifted	100		
Interest thereon	1		
Interest on £1,000, 3% Def. Bonds	30		
		131	
Sale of Car (Morris)		300	
			13,686
Bank Withdrawals			13,628
			£27,400

	£	£
To Accounts owing to the farm at the beginning of the year	1,611	
,, Accounts owing by the farm at the end of the year	457	2,068
,, Balance, being Net Profit for the year		1,680
		£27,576

	£	*Cr.* £
By Sales—		
Cattle	1,654	
Sheep	488	
Potatoes	1,722	
Grain	1,258	
Milk	7,678	12,800
,, Subsidies—		
Ploughing	85	
Potato	250	
Lime	110	445
,, Shooting Rent		10
,, Allowance for value of food consumed	70	
,, Allowance for Rent, Lighting, etc.	30	100
,, Stock on hand at end of year ...		11,844
		25,199
,, Accounts owing by the farm at the beginning of the year	677	
,, Accounts owing to the farm at the end of the year	1,700	2,377
		£27,576

BALANCE SHEET AS AT 31st MARCH, 1953

LIABILITIES

	£	£
I. Sundry Creditors		457
II. Capital—As at beginning of year ...	16,953	

		£	
Add—			
Cash paid in during year ...		131	
Net Profit for year		1,680	
Gain on realisation of motor car		80	
		18,844	
Deduct—			
Produce consumed, etc.	£100		
Personal drawings ...	540		
Income Tax	410		
		1,050	
			17,794

Note—The Capital of the Farm at the beginning of the year is arrived at as follows :—

Valued at 31/3/53	£
Plant	4,420
Debts owing to the farm ...	1,611
Total of Inventory	10,935
Cash in Bank	578
Cash on Hand	86
	17,630
Less Debts owing by the Farm	677
Capital at beginning ...	£16,953

£18,251

ASSETS

	£	£
I. Fixed Plant—		
As at beginning of year	700	
Less Depreciation at 5 per cent.	35	
		665
II. Implements—		
As at beginning of year	1,800	
Add Purchases	100	
	1,900	
Less Depreciation at 10 per cent.	190	
		1,710
III. Reapers and Binders—		
As at beginning of year	200	
Less Depreciation at 15 per cent.	30	
		170

IV. MOTORS—		£	£
As at beginning of year		920	
Add Purchases		700	
		1,620	
Less Sales	£300		
Less Gain on Realisation of Morris car ...	80		
		220	
		1,400	
Less Depreciation at 20 per cent.		280	
			1,120
V. TRACTORS—			
As at beginning of year		800	
Less Depreciation at 22½ per cent.		180	
			620
VI. SUNDRY DEBTORS			1,700
VII. STOCK ON HAND—			
Live Stock (Trading)		8,168	
Grain, etc.		1,341	
Cultivations		1,885	
Miscellaneous		250	
Loose Tools		200	
			11,844
VIII. CASH—			
On Hand		70	
In Bank on Current Account ...		352	
			422
			£18,251

There is no need to make a complete Inventory of Machine and Plant each year. To the original Inventory any machine purchased during the year should be added or any machine sold or scrapped deleted. If the list of these items is in go order it is a simple matter to prepare a statement bringing out t Wear & Tear Allowances to be claimed as a deduction from t Income Tax Assessments. The Inspector of Taxes will work t out if called upon to do so.

GENERAL NOTES—Owner-Occupier—In this case t farmer is his own landlord and does not pay rent as would ordinary occupier. Either of two methods may be followed : A separate Bank Account called " Property Account " may kept into which is paid a half-yearly rent for the farm ; in other words a cheque is drawn on the farm account for the rent and paid into the " Property Account." That account then bears all the landlord's charges arising out of ownership, such as Owners' Rates, Income Tax—Schedule " A," and any burdens on the land which are paid under deduction of Tax, such as Feuduty, Ground Rent, Stipend, Multures, Interest on Mortgage, Redemption Annuity payable under the Tithe Act, 1936, Land Tax (if any) and also the cost of repairs to the buildings, these being restricted to those repairs which are necessary to " maintain the rent." By following this system the interest as owner is kept apart from that of the occupier. Under the second method all Property Expenses may be charged to the farm, make no charge for rent but at the end of the year charge the Profit & Loss Account with what is known as " Nett Schedule A," i.e., the nett rent on which Property Tax is calculated. The second method is recommended.

Wages—Wages may be dealt with in two ways :—

(*a*) by recording the actual cash paid to the employee. This method will involve an adjustment at the end of the year for Board, and

(*b*) recording the money wages as well as the cost of boarding the employee. The total entry in this case would be the wages they would receive if they were not boarded in.

Method (*a*) is the one recommended.

If members of the family are employed there should be included in wages only the actual *bona fide* payments made to these members. These persons should be treated exactly in the same way as any other employee and a reasonable wage recorded in the Cash Book for their services. The question of Board of all employees, including family, will be dealt with at the end of the year.

Private transactions—As already mentioned in these notes, all income and expenditure should be recorded in the Cash Book so that the cash may balance. That book contains therefore, on the receipts side, a record of the receipt of dividends, sales of private property, legacies, sales of investments or any other private transactions, and on the payments side all private and household payments, including tradesmen's bills. This method should be followed unless the farm system is highly developed and there is a separate Bank Account for personal transactions. It is assumed that this is not so. At the end of the year the Accounts owing by and to the farm (shown as part of the

Inventory) will *exclude* all such private transactions. It wil be observed that the private transactions are excluded from th Profit & Loss Account as they are not sums expended for th purpose of earning the profit. They would occur whether or no the land was being farmed. They are properly dealt with a Capital transactions.

Claim for Wear and Tear of Plant and Machinery—Mone expended on acquiring plant is not an expense of running farm; it is an investment of capital, and in the same wa money realised from the sale of machinery and plant does no represent a profit—it represents a realisation of capita Machinery and Plant, however, wears out by its constant use and it is prudent to make an allowance each year for the value o this Wear & Tear. Such an allowance is admitted by th Inland Revenue and is granted as a deduction from farm profit It is not intended here to deal with the Income Tax position an these notes deal only with the allowance which should be made i the farm Accounts in order to arrive at true profit. (Certai allowances granted as a deduction from income for taxatio purposes, such as the Initial Allowance under Sections 15 and 3 of the Income Tax Act, 1945 are also ignored.) The percentag rates of Wear & Tear in general application for the differe classes of farm plant and machinery are based on the followi figures and should be used for the purpose of making th allowance annually from the farm profits :—

TABLE 196

Class of Machine	Annual Rate of Wear & Te Allowance
1. Boilers and Engines ...	5 per cent. or 1s. per £
2. Electrical installation ...	7½ per cent. or 1s. 6d. per £
3. Binders, Reapers and Combine Harvesters	15 per cent. or 3s. per £
4. Motor Lorries	20 per cent. or 4s. per £
5. Tractors	22½ per cent. or 4s. 6d. pe
6. Sprayers, Flax Pulling Machines	25 per cent. or 5s. per £
7. All other types of farm machinery, including portable poultry and other Houses	10 per cent. or 2s. per £

(For Income Tax purposes the Inland Revenue increase th rates by one quarter.)

The following is a statement of the Wear & Tear Allowances under Income Tax Law applicable to the farm under review :—

WEAR AND TEAR ALLOWANCES

	Plant 5 per cent.	Implements 10 per cent.	Reapers and Binders 15 per cent.	Motors 20 per cent.	Tractors 22½ per cent.
Assume the values brought forward from previous year 1952 ...	£ 700	£ 1,800	£ 200	£ 920	£ 800
PURCHASED during year		100		700	
	700	1,900	200	1,620	800
SALES, being the written down value				220	
	700	1,900	200	1,400	800
*INITIAL ALLOWANCE (being 20 per cent. of purchase price) ...		20		140	
WEAR AND TEAR (at above rates plus one quarter)	44	238 258	38	350 490	225
CARRY FORWARD ...	£656	1,642	162	910	575

*Initial allowance is now 40 per cent. as from 6/4/49.

The statement commences with the written down value of the items at the beginning of the year, to which is added the purchases and from this total the written down value of Sales is deducted. From the remaining total the Initial Allowance on Purchases and Wear & Tear at the appropriate rates on these remaining totals is deducted. The balance, representing the written down value *for Income Tax purposes*, is carried forward to the following Income Tax year.

GLOSSARY OF FINANCIAL TERMS IN SIMPLE FORM.

Profit—All Cash or goods received, which does not require to be repaid, is a " Profit."

Loss—All cash or goods given away, which will not be recovered, is a " Loss."

Trading Profit is the excess of Profits (i.e., Trading Income) over Loss (i.e., Trading Expenses). The profit derived from the sale of goods in which the farmer does not trade is not a profit of the farm (it is not subject to Income Tax), i.e., the sale of t goodwill of a Milk Run, the sale of the farm itself or part of may show a profit over cost but these are not "trading" prof and are not subject to Income Tax.

Until the Income Tax Act of 1945 the profit derived from t sale of Implements, Tractors, Motors, etc., was not taxab Now any profit on such sales is taxable, but on the other ha any loss is allowed against farm profits. To arrive at the res to the farmer in terms of the above Act requires special co sideration and computation.

Asset—All cash or goods given away which will be eventua recovered is an "Asset."

Liability—All cash or goods received which will requ eventually to be repaid is a "Liability."

Capital—The Capital of a farm is the Excess of the value of t Assets over the amount of the Liabilities. If the Liabil exceed the Assets the farm is insolvent.

Depreciation or "Wear and Tear" is an estimate of amount by which Plant, Implements, etc., falls in value ea year, due to use, obsolescence, etc. This loss in value is estima by a deduction from the diminishing annual value of a fi percentage.

Cultivations or Tillages represents the value of the acre under crop and is valued on the aggregate value of the se manures, etc., applied to the land and the labour of cultivati The value will vary depending on the date when the Ann Inventory is taken.

Live Stock—Cattle, Pigs and Sheep may be treated in Accounts as Trading Stock or Capital Stock. If the form annual valuations must be made, if the latter, valuations dispensed with, but adjustments are required for additions deductions from the Herd. The following principles apply to

Cattle—All cattle may be included in "Capital" St (i.e., the Herd) if they have entered their first lacta period. Breeding Bulls are included. All other cat such as Heifers, Stirks, Calves, etc., are treated as Trad Stock.

Sheep—Flocks are of two kinds (*a*) bound Stocks (*b*) free Stocks. Under (*a*) all animals including lambs "Capital"; under (*b*) only breeding ewes "Capital," the lambs are "Trading." Thus in all case half-bred or cross bred stocks the breeding ewes only be classed as "Capital." This distinction can be important at annual valuations and on a displenishing In the latter case any profit derived from the sale of Ca items such as the Herd of Cows, the total stock whic bound to the ground and the breeding ewes cannot be ta

FORESTRY

TYPES OF WOODLAND—Woodland may be classified as) Natural, (*b*) Managed.

(*a*) **Natural Woodlands**—There is very little natural woodland Great Britain and human interference has been so great and so rolonged that almost all the woodland in the country, even hough it conforms to recognisable natural types, is at least artly artificial. The general pattern is related broadly to those atural types of forest found where there has been no inter-erence by man or livestock. Thus over the Midlands and the outh of England the principal forest growth is oak ; on the halk and some of the limestones, beech ; in the higher valleys f the Scottish Highlands, pine and birch. The Scots pine is e only indigenous coniferous timber tree. Natural types of oodland :

Oak—(i) PEDUNCULATE OAK—Oak woods in which the edunculate oak is the dominant species have a wide distribution Great Britain and particularly in the Midlands, and in the outh and east of England on the deeper and more fertile soils. Much of this type of forest land is now occupied by coppice-ith-standards.

(ii) OAK—ASH WOODLAND—This type, predominantly oak, ut with an important admixture of ash, is typical of much of the oodland on the calcareous boulder clays of the east Midlands, s for example, in south-western Lincolnshire, Rutland and the djoining districts.

(iii) SESSILE OAK—Commonly found on the siliceous soils f the north and west but also present on the acid sandy soils of outh-eastern England and on the Bunter sand formation in the Midlands.

Owing to widespread planting, mainly of the pedunculate pecies, to make an exact distinction between these and the edunculate oakwoods is difficult.

(iv) OAK—BIRCH—A type found on dry acid sandy soils. is not infrequently associated with plants such as heather Calluna).

Beech—Although planted beech is found almost anywhere in reat Britain, beechwoods of a natural or semi-natural character ccur in comparatively few districts being almost entirely onfined to the Chilterns and Cotswold Hills, and to the North and South Downs. The distribution is thus restricted to the chalk and the limestone.

Ash—Ash appears as a woodland type on the shallower limestone soils and is also found in beech woods at a certain stage in their development. Ash-woods are found frequently on the Jurassic and Carboniferous limestones especially in the west and north.

Alder—Alderwoods occur in small patches in many parts of the country and form a characteristic and well defined type. Along the margins of streams they may be found all over Great Britain but chiefly in the west and north. They are also well developed round the Norfolk Broads and elsewhere in East Anglia. Alder woodland is associated with moist and even waterlogged soils provided these are not too acid.

Pine—The natural woods of Scots pine which still remain in this country are confined to Scotland where they occur in relatively small patches in some of the Highland valleys and lower slopes. As elevation increases they become more mixed with birch and usually pass into birchwood at their upper limits.

Birchwood—Birchwoods are common in the Scottish Highlands often growing at considerable elevations.

(*b*) **Managed Woodlands**—Woodlands in this country fall into three main types of management—(i) High Forest, (ii) Coppice, (iii) Coppice-with-Standards.

(i) High forest is composed of trees of seedling origin and includes all plantations as well as woodlands resulting from natural seeding. High forest may be even aged, as in a plantation or uneven-aged, like many of our larger woodlands when trees of quite different ages occur individually or in groups.

(ii) Coppice consists of a crop originating not from seedlings but from stool shoots. Coppice woodlands, when under management, are cut over at regular intervals to yield poles and other produce. Coppices of chestnut, ash, alder and oak are not uncommon in many parts of England.

(iii) Coppice-with-Standards is much more common in England than simple coppice. Characteristically it consists of coppice through which are scattered a number of trees—the standards—which are allowed to grow to timber size. Under management, the coppice is cut at regular intervals and provision is made for the felling of the standards when they are mature and their replacement by younger trees. A typical example of Coppice-with-Standards is the common hazel coppice with oak standards found all over southern England.

Coppice and Coppice-with-Standards are old systems now passing out of favour, except in special circumstances, becaus there is no longer the large local demand for the small poles so produced. Many have become derelict : others are bein converted into the high forest type. Conversion is possible only with species such as ash, oak, etc., which are capable of growing into trees. Hazel which remains a shrub or small tree cannot be converted to high forest.

STATISTICS OF BRITISH WOODLANDS.

Area—The area of Woodlands in Great Britain is approximately 3,600,000 acres, of which rather more than 3,400,000 are in blocks of 5 acres and over. Of the latter areas 1,865,000 acres are in England, 1,267,000 in Scotland and 316,000 in Wales.

Species—The areas occupied by the principal species in Great Britain are as follows :—

Oak, 431,495 acres, Scots Pine, 364,152 acres, Sitka Spruce, 167,039 acres, Beech, 161,765 acres, Norway Spruce, 133,153 acres, European larch, 132,901 acres, Ash, 84,766 acres, Birch, 67,146 acres, Sycamore, 56,153 acres, Japanese larch, 55,058 acres.

Ownership—The Forestry Commissioners own 623,000 acres of woodland or 18 per cent. of the total. Of this area 288,000 acres are in England, 243,000 acres in Scotland and 92,000 acres in Wales.

State Forests—There are (1950) 351 State Forests in Great Britain, including old Crown Woods such as the New Forest, Forest of Dean, Delamere Forest, etc., 131 of these State Forests are in England, 164 in Scotland and 56 in Wales. The largest are Kielder, Northumberland, 43,000 acres, Thetford, Norfolk and Suffolk, 40,000 acres. Forest of Dean, Gloucestershire, 20,000 acres, New Forest, Hampshire, 20,000 acres, and Warke Forest, Northumberland, Clashindarroch, Aberdeenshire and Loch Ard, Perthshire, each with 16,000 acres.

FOREST POLICY IN GREAT BRITAIN—Great Britain had no national Forest Policy before the 1914–18 War and it was not until 1919 that an organised policy was put into effect. In that year the Forestry Commission was first appointed with the principal object of making the country independent of imported timber for three years in an emergency. To do this it was estimated that in addition to bringing the existing woodlands into full production it would be necessary to afforest 1,770,000 acres of bare land which was not under trees. It was recommended that two-thirds of this programme should be accomplished in 40 years and the remainder between 40 and 80 years after the inception of the scheme. The necessary work was to be carried out by private owners, public bodies and the State, which was to be responsible for the bulk of the new planting. Private owners were assisted by the provision of grants towards the cost of the planting.

During the twenty years between the wars, this programme, with several modifications, was pursued and the result was a substantial increase in the area of our young plantations, particularly those of conifers, but the second war came too soon for these to contribute substantially to the war requirements with the result that the enormous demands for timber for war purposes had to be satisfied mainly out of the already depleted stocks in privately-owned woodlands and plantations. It became apparent before the war came to an end that forest policy would require overhauling in order to meet the situation caused by the war-time fellings and accordingly the Forestry Commission in 1943 put forward their proposals for post-war forest policy. They recommended that the ultimate objective of forest policy in this country should be five million acres of effective forest, of which two million could be secured from existing woodlands by restocking and management, and three millions from the afforestation of bare ground.

As before, the necessary programme involved a joint effort on the part of the State and of the private owners and in order to help private owners to manage their woodlands efficiently and in order to obtain effective production from the existing fores area of the country, the Dedication Scheme was introduced (See page 649.)

BROADLEAVED TREES—The commonest of the broadleaved or hardwood trees are indigenous to Great Britain. In this respect this group of trees differs greatly from the conifers

Oak—There are two species of oak native to Britain, th common pedunculate oak (*Quercus robur L.*) and the sessile oak (*Q. petraea Lich.*), the former with its acorns borne on stems o peduncles and the latter with acorns which are sessile on th shoots. There are various other morphological difference between the species, and forms intermediate in character occu all over the country.

The oaks tolerate a wide range of climatic and soil condition and there are sites where they exist without attaining a timbe size. For good growth, oak requires deep, fertile, well draine soils. Gravelly soils, although they do not affect the growth, ar apt to produce badly shaken timber, while very heavy, badl drained clays, give exceedingly slow growth. The sessile oak to be preferred on the lighter soils. Oaks are easily damaged b frost when young and should not, therefore, be planted in frost hollows. If it is necessary to plant oaks in such a site, the should be mixed with Scots pine or some other hardy species.

Beech (*Fagus sylvatica, L.*)—Beech is a most accommodatin species which grows on many types of soil and is tolerant o slightly acid as well as of alkaline conditions. Peats ar extremely acid podzols, however, are unsuitable. It is probabl at its best on the chalk and limestone but it grows vigorously o any soil which is suitable for oak. Beech withstands exposu well and may be used on sites subject to wind. When young, it is very frost tender and must not be planted in frosty localities without a nurse species such as Scots pine. A mixture with pine, either Scots or Austrian, helps the establishment of beech on thin chalk soils because the shade of the pine kills the grasses which compete severely with the beech for moisture and nutrients. Beech withstands shade and may be used for planting under other trees or for filling gaps in plantations. The shade, so provided, frequently gives the young beech some protection from frost.

Ash (*Fraxinus excelsior, L.*)—The ash is one of our most valuable timbers, with a variety of uses in agriculture, and commanding, when well grown, a high price for special purposes.

Ash requires a deep, fresh soil, calcareous in nature, moist but well drained, and the site should be sheltered because the best growth of ash is never found under conditions of exposure.

Ash is a difficult tree to establish by planting. It is frost tender and does not readily recover from frosting ; it is particularly sensitive to the effects of competition from grass and should never be planted in a grass sward ; it dislikes stagnant water and it is unsuitable for planting in very acid conditions.

Sycamore (*Acer pseudoplatanus, L.*)—Sycamore is commoner and more important in the north of England than in the south, but is widely distributed over the country being associated with ash in many limestone districts. It is rather less exacting than ash in some of its requirements but it requires a deep soil, moderately rich in lime. As a tree for planting, sycamore is subject to the same disadvantages as ash.

Poplar (*Populus spp.*)—There are numerous species and varieties of poplar which can be grouped into three main classes—the aspens, the Balsam poplars and the Black poplars.

Although the aspen (*Populus tremula*), is a native of Great Britain, it is a poor tree and is not cultivated. The Balsam poplars likewise are not favoured, because of their susceptibility to bacterial disease, although one of them, *P. trichocarpa*, grows well in the districts of the north and west to which the disease has not yet penetrated. The varieties which can be recommended for use in Great Britain belong to the third group and are—the Black Italian poplar *P. serotina* and its variety *erecta*, *P. robusta* and *P. gelrica*. These have the advantages of rapid growth and freedom from disease. Poplars are not raised from seed, but from cuttings. They are usually put out when from 6 to 8 feet in height and may be planted either as rooted or as unrooted setts. The latter, if carefully planted in a favourable season, form roots rapidly and grow as well as rooted plants. In an unfavourable season, when a spell of drought follows planting, losses with newly planted unrooted setts may be high. Poplars require much more space than most trees and should not be planted at less than 16 feet apart. They must also be heavily thinned so that competition between individual plants is reduced to a minimum. In this way, usable trees may be obtained in about 25 years.

Poplar is a suitable tree for planting in agricultural districts, either in small copses or spinneys or along streams and roadsides. It requires a deep fertile soil and prefers moist conditions provided the water is not stagnant. Grants are now available for the planting of poplars. (See page 650.)

Willow (*Salex spp.*) Apart from special crops such as osiers, various tree willows have been used in the past in this country, pollarded willows being still a characteristic feature of many of our lowland districts. But, nowadays, the only willow of any importance is the Cricket-bat willow—*Salix alba var coerulea* which is an important crop tree in parts of east and south-east England. This tree can be very profitable to the grower, but to get the best results very careful attention must be paid to the details of the cultural processes.

Birch (*Betula pubescens Ehrh.* and *B. verrucosa Ehrh.*)—Birch is not an easy tree to establish by planting but it seeds naturally in many cut-over woodlands on the lighter soils. These young birch crops are useful if given attention at the right time. Removal of misshapen stems and the gradual thinning of the remainder may result in a useful crop of birch poles.

Elm—The English elm *Ulmus procea Salist.* is rarely found in plantations being essentially a hedgerow tree.

The Wych elm *U. glabra Huds.* which is more frequent in the north of England and in Southern Scotland is better suited to forest conditions but has been little studied in this country and its requirements are not well known. It is very subject to butt-rot if kept standing after it has become mature.

The Sweet Chestnut (*Castanea vesca Gaertn.*)—This tree is less important as a timber tree than as a coppice tree because it is rare to find mature chestnut trees which are not badly shaken The Sweet chestnut does not like highly calcareous soils nor heavy clays but on deep fertile loams and light loams it establishes itself well and grows rapidly. It requires well drained soils and when drainage is bad it is apt to suffer from disease. The chestnut is subject to frost damage when young and should be kept out of frost hollows.

To form a chestnut coppice, young plants should be raised from seed in the nursery and planted out on the site at about feet apart. They may be allowed to grow until they become usable poles before they are cut back, or they may be coppiced five or six years after planting. After they have been cut back coppice shoots rapidly form and the coppice will be ready for management.

Among other broadleaved trees which are occasionally met with in plantations are the lime (*Tilia* sp.) the hornbeam (*Carpinus betulus*) the alder (*Alnus glutinosa*) and the walnut (*Juglans regia*). Apart from the alder, which establishes and regenerates itself in swampy places, such trees are more often planted for ornament than for timber.

CONIFERS—Great Britain has only one native coniferous timber tree—the Scots pine. All other conifers now used so extensively have been introduced from different parts of the world during the last few centuries.

Scots pine (*Pinus silvestris L.*)—This well-known tree is recognised by its bluish green needles, up to 4 inches long, which occur in pairs on the shoots, by its small pointed cones 1 to 3 inches in length and by the reddish tinge of the bark on the upper part of the stem. It is an important timber tree, yielding the familiar red deal of commerce. Scots pine is an accommodating tree growing on most soils although at its best on light sands and gravels. On rich heavy soils, it becomes coarse and branchy, although the rate of growth is not impaired. On chalk, Scots pine does not thrive and although it grows well for a number of years is liable to die suddenly when in the pole stage. This tree withstands moderate but not severe exposure and dislikes salt sea winds. It is frost hardy and is much used in hollows and other frosty sites, either as a pure crop or in mixture with more tender species for protection. It is liable to damage from insects such as the pine-shoot moth and the pine-shoot beetle.

Corsican pine (*Pinus laricio, Poiret*)—A native of Corsica and one or two other localities in the Mediterranean region, this tree has come into prominence in recent planting and afforestation. It has certain advantages over Scots pine, growing faster on certain sites, yielding a larger volume of timber, being much more resistant to insect attack and producing straighter poles which can be converted with little waste. Like Scots pine it has needles in bundles of two but they are longer (4 to 6 inches) and are slightly curled. The bark is grey in colour and lacks the reddish tinge of the Scots pine. Corsican pine is well suited for planting in the drier parts of the country particularly in the south-east and east ; in the southern half of the country it grows considerably faster than the Scots but it can be grown in the north-east of Scotland where, however, it does not grow very much faster than the Scots pine. It prefers light soils, is tolerant of lime and can be used in chalk and limestone country ; it is more resistant to smoke and atmospheric pollution than Scots pine and is thus often used for planting on the Bunter sands an gravels in industrial districts of the Midlands. It withstands se winds.

Corsican pine should not be planted at elevations over 80 feet because on high ground it is liable to die before it has reache pole size.

Austrian Pine (*Pinus nigra, Arnold*)—The Austrian and Cors can pine are usually regarded as different forms of the sam species. The Austrian pine is not recommended for planting fo timber but is useful for shelter particularly near the coast. withstands exposure better than most conifers and is parti ularly resistant to salt sea winds. It also grows on chalk sit where it is often planted with beech which it protects and nurse This tree is similar to Corsican pine but its needles are stiff ar sharp pointed ; it is also characterised by heavy persistent sic branches and, when older, by forked crowns.

Monterey Pine (*Pinus insignis Douglas*, or *P. radiata, Don.*)— native of the Monterey peninsula, is occasionally found in th south west where the climate is relatively free from frost, as, fo example, in Cornwall. In this restricted area, it is a useful shelt tree producing a heavy, dense crown which withstands exposu to sea winds. The needles are in bundles of three and the foliage a rich dark green colour. The cones are 3 to 6 inches long wh mature and are frequently one-sided. This tree has only restricted use in Great Britain.

Maritime Pine (*Pinus pinaster Aiton*)—Is a native of the Med erranean countries and has been planted at various places alo the southern coast of England where it has established itself natural seeding. It is a coarse, flat-topped tree with hea branches and thick bark. The needles occur in bundles of tw they are 5 to 6 inches long and stiff. The cones are large, up 7 inches long and light brown in colour. Unless a better varie or form of this tree can be found, it is not likely to be wor planting in this country.

The Lodge pole pine (*Pinus contorta Douglas*)—Is a tree whi has recently been used in considerable numbers both in Gre Britain and in Ireland for afforesting moorlands. It tolerat very acid soils and is often the only tree which can be relied up to grow on the poorest types of peat. It grows on better so but there is no point in using it where more profitable spec such as Scots and Corsican pines are available. The *contor* is a two-needled pine with short green or yellowish-green needl 1 to 3 inches long. The cones are small and frequently curv with a small prickle on each scale but the most characteris features are the long, resinous buds, like tiny candles.

The European larch (*Larix decidua Miller*)—A native of Cent Europe was first planted as a forest tree in Great Britain in t second half of the eighteenth century. It is now one of our commonest trees. Like other larches, this species is deciduous and may be distinguished from the Japanese larch by its straw-coloured shoots and the shape of its cones, the scales of which are closely appressed and not reflexed at the top, as in the Japanese larch. This larch is an exacting species so far as soil is concerned and is highly susceptible to damage from frost in spring and early summer. Planted in unsuitable soil on a site subject to recurring frost damage, it frequently dies out. Larch can be grown to the size of a small pole on most soils, but on heavy clays, the growth stagnates while on light sands the trees are apt to suffer from butt-rot at a relatively early age. To get the best results larch should be grown on deep or moderately deep fresh soils with an abundance of water during the growing season. It is unsuitable for chalk – most of the successful plantations in chalk districts are not on the chalk but on the clay with flints or the plateau gravels—while it does not succeed on peat. Larch requires to be thinned heavily.

The Japanese larch (*Larix leptolepis Murray*) which came into cultivation in the last quarter of the nineteenth century, is recognised by its reddish twigs, and by its characteristic cones. Its foliage is denser than that of the European larch and the tree throws a much heavier shade. Japanese larch is a more accommodating species than European larch and it is particularly valuable in the afforestation of moorlands where it establishes itself quickly if the peat is shallow. It is sensitive to drought and for this reason should not be planted on soils which tend to dry out severely. Although it is injured by late spring frosts, it usually recovers well from frost damage and is preferable to European larch in frosty situations. Japanese larch is more resistant than most conifers to the effects of smoke and industrial fumes.

The Hybrid larch (*Larix eurolepsis Henry*) which was discovered in 1905, at Dunkeld in Scotland, is a cross between the two species already mentioned. It is vigorous in growth and is a promising tree being more accommodating than the European larch on a wide variety of soils.

The Douglas fir (*Pseudotsuga taxifolia Britton*) is a native of the Pacific coast of North America, whence it was introduced in 1827. It is capable of reaching a large size in this country. On favourable sites, growth is rapid, exceeding that of most other conifers but really good sites are not common. The Douglas fir may be recognised by its pointed reddish buds, by the pectinate arrangement of its needles and by its cones, 3–4 inches in length, which are pendulous. The cones have characteristic three-lobed bracts.

This species is highly sensitive to exposure and must no
planted on sites where this factor is important. It is also sub
to severe frost damage. It is accommodating as to soil
grows on a wide variety of soils excepting those which
highly calcareous or markedly peaty. On heavy soils, it is
to become rank and is liable to be thrown by wind espec
where the drainage is imperfect.

The Norway spruce (*Picea abies Karsten*).—A native of cen
Europe, the familiar Christmas tree has long been cultivate
Great Britain. It requires a moist, well-drained soil, flourishes
on well-drained loams where the rainfall is at least 40 inc
On light sands and in districts of low rainfall, this tree may g
moderately well for a number of years but it loses vigour a
early age and frequently suffers from butt-rot. It will not g
on calcareous soils but it thrives on the better types of peat.
relatively frost hardy but is easily damaged by blast and pa
ularly by sea winds. Norway spruce, which is generally pla
in moist situations, dislikes stagnant water; it is therefore v
important to see that plantations are kept well drained.

The Sitka spruce (*Picea sitchensis Carr*).—A native of the
board of western North America, has been widely used during
last thirty years in British forestry. It may be distinguished
the Norway spruce by its bluish-green needles which are sh
pointed and by its cones which are 2–4 inches long and have
almost papery scales. The cones of Norway spruce, on the o
hand, are 4–6 inches long, rich brown in colour and with tou
scales. Sitka spruce is more easily damaged by frost than Nor
spruce but withstands exposure more successfully. It g
on all soils where Norway spruce can be used but can als
planted with some success on the poorer and more acid p
The rate of growth is substantially greater than that of
Norway spruce.

Among other conifers which are met with from time to
in plantations in this country are the Western Red C
(*Thuja plicata*) and the Lawson cypress (*Chamaecyparis* w
have the flattened branchlets characteristic of some of
Cupressineae, and the Western Hemlock (*Tsuga heteroph*
which may be recognised by its graceful habit, its small le
¼–¾ of an inch in length and its tiny cones which are less th
inch long.

Various other conifers are met with in parks and gar
Among these are three species of Cedars — the Ced
Lebanon (*C. libani*) the Atlas Cedar (*C. atlantica*) and
Deodar (*C. deodara*).

EES FOR VARIOUS SOILS.

Acid Peat Soils—(i) With *Scirpus caespitosus* and *Calluna* in herbage. Generally regarded as unplantable by normal thods.

ii) With *Calluna* and *Molinia*. A mixture of pine (Scots e or *P. contorta*) and Sitka spruce.

iii) With *Molinia* dominant. Sitka spruce.

Less Acid Peat Soils—With *Juncus* and Grasses. Norway ruce.

Alkaline Fen Peats—Poplar (if water table is not too high). der.

Moorland Soils—Usually with *Calluna* dominant or abundant the herbage: with a thin, dry peat and with the soil more or s leached in the upper layers. In low rainfall districts, Scots e should be the principal species. Douglas fir may be used mixture with the pine.

Where rainfall is more abundant, use should be made of panese larch. Sitka spruce should also be tried preferably in xture with Scots pine.

Hill grassland and bracken—When bracken growth is heavy, is often advisable to plant Japanese larch and, in sheltered ces, Douglas fir which are capable of suppressing and othering this fern. European larch may also be planted but lighter shade does not have the same effect in killing the acken.

On hill grassland, Norway spruce, Sitka spruce or Japanese rch may be used, particularly in the wetter districts while ep, fresh soils may be successfully planted with European ch. The appearance of heather or bilberry among the grass licates the advisability of using Scots pine.

Chalk Downland—The best tree for afforestation on this land beech but as this species is subject to damage from frost and om sun-scorching it is best to mix it with pine (Scots, Corsican d Austrian) at the time of planting. The pines give the young ech the necessary protection and can be cut out when the ech are well established. Plantations of larch and other ecies are often successful on chalk hills but they are usually owing on the clay-with-flints or plateau gravels on the tops. ey are not likely to succeed on chalk escarpments.

Lowland Soils—(i) Light sandy soils—Scots pine and rsican pine. The latter is preferable in the south and south-st of the country.

(ii) Medium sandy soils and light loams—Most of the nifers succeed on these soils, although the spruces and panese larch are apt to cease growing vigorously at an early e if the land is subject to drought.

Of the hardwoods, oak, beech, lime, birch and, if the soil is slightly acid, sweet chestnut all grow satisfactorily.

(iii) Loams—Pines, especially Scots pine, tend to grow coarse and rank on good loams but larch, spruce and Douglas fir flourish.

Most of the hardwoods can be used. If the ground is wet but not waterlogged poplar may be grown.

(iv) Clays—Clays, generally, are unsuitable for conifers All the hardwoods may be grown but they do not establish themselves very quickly.

Frost-Hardy and Frost-Tender Trees—Winter cold does not normally affect the timber trees commonly grown in this country. Late spring and, to a less degree, early autumn frosts are damaging to numerous species.

The effects of these frosts are twofold :—

(i) delaying the establishment of young crops by cutting back and sometimes killing the small trees.

(ii) restricting seed production on mature trees by killing the flowers.

The common trees may be classified in respect of their resistance to late spring and early autumn frosts in the following way :—

Frost Hardy—Scots pine, Birch, *Pinus contorta*, Hornbeam; Elm.

Moderately Frost Hardy—Corsican pine, Norway spruce Japanese larch.

Moderately Frost Tender—Oak, Sycamore.

Frost Tender—Beech, Ash, Sitka spruce, Douglas fir, European larch.

Trees and Exposure—Constant exposure to wind ha an adverse effect on growth. This is more severely felt by isolated individuals for it is noticeable how, in a wood on an exposed site, the trees on the windward edge are small and relativel stunted whereas those in the centre, sheltered by the edge trees are much better developed. Some species are more subject to damage than others and it is important to know which are susceptible because of the increasing importance of planting fo the purpose of giving shelter.

Generally speaking, the common hardwood trees, if the sit is otherwise suitable, are resistant to exposure ; the poplar are possibly an exception to this rule as some varieties appear t be easily damaged by wind. This genus has not yet bee sufficiently studied, however, to make any definite pronounce ment possible.

Of the conifers, Corsican and Austrian pines, the larches an Sitka spruce are resistant to exposure and so is Scots pi except at high elevations. Norway spruce is only moderatel resistant while Douglas fir should not be planted on exposed sites being highly susceptible to damage from exposure to wind.

Exposure to salt sea winds affects some species severely, of which Scots pine and Norway spruce are good examples. Neither should be planted close to the sea.

Austrian pine and Sitka spruce are remarkably resistant to salt-laden winds coming from the sea.

Shade Tolerance of Trees—Trees can be divided into two classes in respect of their light requirements, viz. "light demanders" and "shade bearers." Light demanders are intolerant of shading by their own or by other species ; shade bearers tolerate the shade of other trees standing over them.

In planting mixtures or in underplanting one crop with another, it is important to know the degrees of shade tolerance of the different species.

Tolerant of Shade—Conifers :—Yew, Silver firs, Thuya, Lawson cypress, Douglas fir, Norway spruce. Hardwoods:—Beech, Hornbeam.

Moderately Shade Tolerant—Conifers :—Sitka spruce. Hardwoods :—Sycamore, Sweet Chestnut, Lime.

Intolerant of Shade—Conifers :—Scots pine, Corsican pine, European larch, Japanese larch. Hardwoods :—Poplar, Oak, Ash, Elm.

Trees which are intolerant of shade generally cast a light shade themselves and they can be underplanted with shade tolerant species. It is not safe to attempt this, however, until they have reached a considerable height with their canopy thirty to forty feet from the ground. Young crops of pines and of Japanese larch throw a heavy shade and the last-mentioned in its young stages can suppress species like Douglas fir.

Planting for Shelter—Plantations of trees may be used to provide shelter of a semi-permanent kind to houses and buildings, to agricultural land, and to stock. The purpose for which the shelter is required governs to a considerable degree the type of plantation which is established and determines its size, shape and location.

Shelter belts and shelter plantations reduce the velocity of the wind and this effect is felt for a distance to leeward of about ten times the height of the sheltering trees. Beyond a distance approximately equal to five or six times their height, the effect is relatively unimportant. Plantations to windward of houses and buildings have the effect of increasing the winter temperature in the sheltered structures.

In planting to shelter houses and buildings, trees should be so placed to prevent over-shading and to ensure when they reach maturity damage to the structures is avoided if they fall or are blown down. They must not be placed so far away that the maximum benefit of the shelter is lost. A distance equivalent to 1½ times or twice the probable final height of the trees will be safe and effective.

Poplars are troublesome, particularly in clay soils, if they are placed less than thirty yards away from a house. Their vigorous wide-ranging, surface roots by taking moisture from the soil may cause local subsidence in a dry season and cause cracks in walls

Shelter belts are sometimes necessary to prevent wind erosion of the soil, a not uncommon phenomenon in the Fens and on the light lands of East Anglia and elsewhere. Here narrow belts are usually adequate because even single lines of trees have an appreciable effect. Belts of half a chain to one chain in width are effective, especially if they can be repeated at frequent intervals On hill land, where shelter to stock is the primary consideration belts should be wider and longer. The winds are generally stronger on such sites and a much greater benefit is obtained from thick belts. Two and a half chains is the minimum effective width on hill land.

Shelter belts should be designed to lie at right angles to the direction of the prevailing wind and the longer they are, the greater the area protected effectively. On hill ground, however there are numerous local variations of wind direction which require close study before a belt is finally sited. In upland valleys the wind normally blows up and down the valley and it i usual to run the shelter belt up the slope at right angles to the direction of the valley. Local changes of topography, however may bring in winds from side valleys or downdraughts from higher slopes and for this reason belts are often planted a critical points in the shape of the letters L or T.

The outside branches of a shelter plantation should never b brashed or pruned because a shelter belt loses some of it effectiveness when the wind can blow through it.

Planting for Timber—Any timber produced in shelte plantations is really a by-product, subsidiary to the mai object, the provision of shelter. Planting for timber requires different approach and afterwards a more intensive programm of management

Shelter plantations must, of necessity, be planted in expose situations ; for timber the best results are obtained by plantin in sheltered sites where a wider range of species can be used t reach a greater height and larger size than is possible in expose situations.

Similarly, for timber production, good land offers the choic of more numerous and more valuable species, it gives a highe rate of growth and the probability of a crop of timber in a shorter time than land of low fertility. These are considerations which should weigh with the private landowner in making his decision on the selection of land for planting.

Planting for shelter is usually more expensive than planting for timber production, because the shape of the normal shelter belt, long and narrow, involves the expenditure on fencing of an nordinately high sum per acre of land enclosed. Plantations of this shape are unsuitable for timber production because they contain too high a proportion of edge trees and the full possibility of growth inherent in a species cannot be realised on sites when there is exposure unless the plantation is sufficiently deep to overcome this " edge " effect.

Generally, therefore, small plantations (say 5 acres and under) are unsuitable for timber production on ground affected by exposure as they contain a high proportion of stunted and malformed stems. Small plantations are best confined to places where there is some shelter for example in side-valleys, combes, dingles and odd corners of sheltered farm land. On other sites, the larger the plantation, the better.

Preparation of Ground for Planting—The amount of ground preparation necessary prior to planting depends on he type of land and on its use immediately before afforestaion or re-afforestation. Old woodland, derelict agricultural and, rough pasture, heather moorland and peat land all require different treatment.

Old coniferous woodland rarely requires special treatment, apart from drainage to remove any excess of water, and new planting can be carried out among the stumps of the old crop, provided these are old and dry enough to be unattractive to the pine weevil. If the weevil is still present in the stumps, planting should be delayed until all risk is past.

Old broadleaved or hardwood woodland is generally much more difficult to prepare for new planting. It is generally ound on more fertile soils than old conifer plantations which esults in a heavy growth of vegetation including numerous woody species. Also, the old hardwood trees coppice from the tump and strong new growths are often produced in this way while many of the limbs and branches of the former crop trees are frequently left on the ground and in course of time these become overgrown with brambles, thorns and other creepers. The drainage system, important on heavy soils, may have been wrecked by the removal of the previous crop which results n waterlogged conditions. The longer the replanting of hardwood areas is delayed, the greater the expense of bringing them nto a condition fit for replanting and it is advisable therefore to restock them as soon as possible after felling.

Lop and top should be collected and removed or burnt o site ; weed growth should be cut along the lines where the plants are to be inserted, and, if this is done, the planting c carried out relatively cheaply. When, however, such a site been neglected for a number of years, the expense of clearin mass of coppice and weed growth in order to replant is exces If the coppice shoots are growing reasonably straight, they be allowed to grow on with the intention of thinning them and underplanting with a more desirable species or the co total clearance may be reduced by cutting lanes or groups i mass of growth and planting these cleared areas. This wi give a wholly satisfactory crop, but it may be the best whic be done in the circumstances.

Derelict agricultural land is more easily treated. Whe from bushes, wide single furrows at the correct distance for the species to be used should be ploughed, the young being planted in the furrow bottoms. This gives the plants an advantage by removing for a time the comp vegetation which hampers their establishment. Bushes ca pulled out with a tractor.

On most rough and hill pasture, where ploughing is normally possible, little preparation of the ground is nece before planting. On dry slopes, with a thick grass s young trees may suffer from intense root competition possibly from nitrogen deficiency. It is usually an advanta these conditions to remove the grass from the spot whe plant is to be inserted. This operation, "screefing," can be with the broad end of a mattock, the pointed end of whic be used for the actual planting.

Much planting is done nowadays on heather moorlan peat but these difficult types of soils should not be pl without obtaining expert advice. Ploughing is now gen used, but special ploughs are necessary, in the one cas break the pan and, in the other, to cut the drains whic essential.

Fencing of Plantations.—Seldom can plantations be successfully without fencing. In almost every case plantations must be fenced against rabbits or stock or and even where rabbits are not numerous it is advisab fence against them as an insurance.

The fencing must be fairly durable because a young cr trees is not safe from damage by rabbits until a dozen after planting while the smooth-barked hardwoods m attacked when quite large. Generally speaking, shee cattle do not damage young trees after they have formed c If fences are maintained up to the time of the first thinning r able protection is obtained.

A stock proof fence which excludes sheep effectively can be ade by using five plain galvanised wires (No. 8) with a top wire barb at 4 ft. above ground level. Strainers should not be re than 150 yards apart, while the intermediate posts should at three yards intervals.

A stock-and-rabbit-proof fence can be erected to the same ecification but with rabbit netting 42 inch by 1¼ inch 18 uge) fixed on the inside of the fence and let into the ground a depth of about 6 inches. The netting may be erected on the tside of the fence if it is unlikely to be damaged by horned ttle and in this case, fewer wires may be used.

A fence proof against rabbits only may be constructed by ing a plain or barbed galvanised wire, stapled above the tting with another plain wire, lower down behind the centre the netting. The netting—42 inch by 1¼ inch 18 gauge—ould be tied to the top wire and should be let into the ground. this cannot be done, the bottom 6 inches of the netting ould be turned out along the surface of the ground and kept in ition with sods laid upon it.

Drainage of Plantations—Trees will not normally grow in aterlogged ground and efficient drainage is a prerequisite success in planting on land permanently or intermittently et. The drains used in forestry are open ditches or channels. le drainage is not used.

Where patches of wet ground result from a spring, cutting a ain to lead the water away by the most convenient and ortest route is necessary. Where the trouble is caused by ater coming in from adjoining higher ground, it may be cessary to dig a cut-off or trap drain around part of the riphery of the planting site. This drain should be, as nearly possible, at right angles to the flow of the incoming water and ould lead to an adequate outlet. If this drain is long or if it ust carry considerable quantities of water, it may be advisable tap it at one or more places to prevent overflow.

These drains should have enough gradient to allow the water flow freely and the gradient (and the direction) should not be ddenly altered as sharp changes in direction and slope may d to scouring, undercutting of the sides or to silting up.

Where it is necessary to deal with water accumulating on the rface of the planting site, a system of secondary drains leading to the main channels should be cut. These may be spaced 20 30 yards apart. The drainage of peat land requires special eatment if the peat is deep and an expert in the afforestation of is kind of land should be consulted before any drainage works e undertaken.

Forest drains are usually about 15 inches in width at the top d 6 inches at the bottom with a depth of 9 or 10 inches. The main ditches are usually wider at the top and up to twice the depth of the subsidiary drains.

Plant Supply—It is doubtful whether a planting programme of less than ten acres a year justifies the establishment of even a small nursery and when small areas are planted a irregular intervals, plants should be purchased from a good nurseryman specialising in forest trees. For all species, with the exception of poplar and willow, rooted plants raised from seed are used. They may be seedlings, one, two, or even three year old, but, more usually, transplants are used. The intending purchaser should verify that the plants have stout shoots an branches, plump, well-filled buds, and sturdy stems. Coniferou plants should also be judged by colour of foliage and length o needle for deficiencies in plant nutrition affect both characters Conifers with yellowish foliage and needles less than the norma length should be avoided. The roots should be bushy and well furnished and there should be a reasonable balance between th root and shoot systems. A top-heavy plant with obviously mor shoot than root is rarely satisfactory and those which have take five or six years to reach the required size instead of three o four years are clearly lacking in vigour.

Seedlings are not used so frequently as transplants in planting except for oak, of which one-year and two-year old seedling have been found to give good results. For other hardwoods an for conifers, transplants are in general use; nevertheless strong seedlings are often employed successfully. They are no so reliable, however, and may suffer heavy losses if a drough follows planting.

Transplants are described in the nursery trade according t age and the number of times transplanted. Thus, a plan referred to as a 1 yr. + 1 yr. + 1 yr. has been transplanted as a on year seedling, kept in the transplant lines for one year and the replanted for another season to be lifted as a three-year-ol plant; a 2 yr. + 2 yr. transplant is obtained from a two yea seedling lifted from the seedbed and allowed to remain for tw seasons in the transplant lines from which it comes out as a four year-old. Plants remaining undisturbed in the transplant line for two years are generally larger than stocks of the same a lifted and retransplanted at intervals of one year but are apt check for a year or two after planting.

Large transplants are preferable to small ones in situatio where weed-growth is likely to be strong. Elsewhere, they hav the disadvantage of requiring more careful planting, while exposed sites they are liable to work loose in the soil under t influence of the wind. Large transplants also cost more th medium-sized or small plants.

The following planting stocks are recommended for the ommoner species on sites of average character.

TABLE 197

Species	Age of Plants	Size in inches
Scots pine	1 yr.+1 yr. or 2 yr.+1 yr.	8–15
Corsican pine	,,	5–12
Larches	,,	12–24
Douglas fir	,,	12–24
Norway spruce	2 yr.+2 yr.	12–18
Sitka spruce	2 yr.+1 yr.	12–18
Oak	1 yr. or 2 yr. seedlings	8–18
Beech	2 yr.+1 yr.	12–24
Ash	2 yr.+2 yr.	24
Sycamore	,,	24

Poplars and the Cricket-bat Willow are not raised from eed but from cuttings taken from suitable trees and rooted in he nursery.

Poplars should be put out when strong plants, six to 10 feet igh. A good nursery soil produces such stock in two or, at the nost, three years. They are usually planted as rooted cuttings ut setts are sometimes employed. These are strong erect shoots vhich are severed from the roots at ground level and are then lanted firmly in the soil. Unrooted sets of poplar can develop oots of their own with remarkable rapidity after planting.

Cricket-bat willows are planted as sets or as rooted cuttings vhich must be carefully selected, perfectly straight, and at least ight feet in height.

Cuttings and sets of these trees should not be purchased vithout a guarantee they are true to name. This is essential vith cricket bat willow which is a specially selected variety.

Planting Distances — Spacing is important because a ubstantial part of the expense of planting lies in the cost of the lants. The minimum number needed to cover the ground nd meet the silvicultural requirements of the species should e used. Trees planted too far apart take longer to form a anopy with which to dominate and suppress weed-growth and ence lead to an annual expenditure for weeding over a longer eriod. If planted for shelter they take longer to provide it vhen spaced too widely ; if grown for timber, heavy branches nd larger knots are produced unless they are artificially pruned. ertain trees, such as the poplars, demand light and room and nust be spaced widely at the very outset, and kept from overrowding. If this is not done, the growth stagnates very quickly nd a disappointing crop is obtained.

Close spacing involves much greater initial outlay than wide spacing but this extra cost may sometimes be recovered if there is a good market for small poles which can be removed in thinnings. Close initial spacing means more trees on the ground and if the plantation is thinned out, as it should be, before the trees have begun to compete severely with each other, a comparatively large number of poles may be taken out in the first thinning. Small poles of larch may be produced profitably in this way when a market is available, but close planting for this purpose should never be undertaken unless there is reasonable certainty of a market. If outlets for the produce are poor, extra expense is incurred in cutting out a large number of small poles in the first thinning.

TABLE 198

Number of Plants per acre required for planting at different spacings.

Spacing feet	Number per acre	Spacing feet	Number per acr
3½ × 3	4,840	8 × 8	680
3½ × 3½	3,546	9 × 9	537
4 × 4	2,722	10 × 10	436
4½ × 4½	2,150	11 × 11	360
5 × 5	1,742	12 × 12	302
5½ × 5½	1,440	15 × 15	193
6 × 6	1,210	16 × 16	170
6½ × 6½	1,031	18 × 18	134
7 × 7	889	20 × 20	109
		25 × 25	70

The following spacings may be used with safety on average sites for various common species.

Oak, 4 feet by 4 feet.

Scots pine, Corsican pine, Beech, Ash, Sycamore, 4½ feet by 4½ feet.

Norway spruce, 5 feet by 5 feet.

European larch, Japanese larch, Sitka spruce, 5½ feet by 5 feet.

Douglas fir, 6 feet by 6 feet.

Poplar, 18 to 24 feet.

Methods of Planting.

(*a*) **Pit planting**—In this method a hole is dug, with a spade large enough to take the roots of the tree to be planted. Fo large scale work it is expensive and is now rarely use although it gives excellent results. Almost the only trees apart from specimen trees, now planted in pits are rooted se of poplar which well repay careful planting.

(*b*) **Mattock Planting**—On steep hillsides, where there is no peat, the mattock is a useful planting tool. The broad end can be used to clear the vegetation from spots where the young trees are to be planted. The pointed end of the mattock is used to make small pits in the soil, into which the plants are placed and firmed with the foot. Mattock planting is effective on slopes where the plants are not too large.

(*c*) **Notch Planting**—Most of the planting in this country is done by this method. There are various forms of notch but the essence of the operation is that a space is opened in the soil wide enough to take the roots of the young tree and is then closed again quickly as soon as the roots are in position. Two common types are the L notch and the T notch. In the L notch, a cut is made with an ordinary garden spade which is driven into the soil to a depth of several inches. The spade is withdrawn and another cut is made at right angles to the first, the two cuts forming a letter L. The spade is levered back so that a wedge-shaped block of soil is slightly raised and the roots of the plant are inserted at the angle formed by the cuts. The soil then falls back into position over the roots of the plant and is firmed with the heel. The T notch is similar but the cuts are made in the form of the letter T.

Another form is the vertical notch, in which the spade is driven straight down into the soil and levered sideways until a notch is made. The plant is then inserted alongside the spade which is then withdrawn and used for firming the young tree.

Notching is an expeditious and cheap method of planting giving good results when carefully carried out.

(*d*) **Turf Planting**—When young trees are planted directly into peat, their roots die and the plant has to keep itself alive until a new root system is formed. The new roots are put out at the surface of the soil and run in the superficial layers only. The method, known as turf planting, makes use of this phenomenon. A block of peat usually about a foot square and four to six inches in depth is cut and placed on the surface of the soil. A cut is made through one side of the turf, as far as the centre and the plant is slipped into this cut with its roots spread out between the turf and the original surface of the bog. By this method, the young trees usually establish themselves quickly without a check as happens when planted directly into the peat. Turves for planting are usually obtained from the drains which must be cut.

Maintenance of Plantations—Plantations of trees require attention throughout their life-time and certain operations must be carried out at the right time if the crop is to develop satisfactorily. These are :—

(i) beating-up ; (ii) weeding ; (iii) cleaning ; (iv) brashing ; (v) thinning ; (vi) maintenance of drains ; (vii) maintenance of fences.

(i) **Beating-up,** a term used to describe the replacement of trees which have died after planting, This should be carried out as soon as possible certainly not later than the second year after the formation of the plantation. If the failures are less than 15 per cent. it is unnecessary to replace them unless occurring in one group or the spacing of the original plants was six feet or more. Losses higher than this figure should be made good. If, for any reason, beating-up is delayed beyond the second year, it is a mistake to put a new plant exactly on the site of the dead one unless the original spacing was wide. Instead, it is better to replace two dead trees side by side with one new tree planted midway between them. This prevents the suppression of the new plant by the growth of those planted several years earlier.

(ii) **Weeding**—There are very few sites where weeding is not necessary. To prevent smothering it is necessary to keep young trees free from vegetation until they are tall enough to surmount it. Light, dry soils do not normally produce heavy weed growth and one weeding usually suffices ; heavy, rich land may need several weedings in the first year or two. Bracken is particularly troublesome especially in late summer and autumn and if not cut well back from the plants lodges on top of them during the winter causing serious damage.

Weeding is best carried out with an ordinary reap hook ; a stick carried in the left hand is useful for locating small trees and for protecting them from the hook. Woody growth is best cut with a hedge-knife or slasher.

(iii) **Cleaning**—When the plantation is reasonably fully stocked and no longer needs weeding, it can be regarded as established and requires little attention until the trees commence to form canopy and the lower branches begin to die. From time to time it may be necessary to remove bushes of willow, other shrubs and small trees which have seeded into the plantation. This operation or " cleaning " should be effected with discretion. Seedlings of valuable tree species such as oak or ash may establish themselves naturally in the plantation ; these should be cut out only after careful consideration.

(iv) **Brashing**—When the trees form a continuous canopy the lower branches begin to die. They should be removed, if they are not shed normally, from all or some of the trees in the plantation. This operation is known as " brashing."

This practice affords access to the plantations and enables the man in charge to examine the crop ; it enables the tree to put on clean, knot-free timber near the butt, the most valuable part of the stem ; it facilitates subsequent operations such as thinning. These are substantial advantages, but brashing is expensive and it is doubtful whether brashing of every tree can be justified. It is better to brash those trees which are likely to remain as part of the crop for some years and to avoid treating those which come out in the earlier thinnings.

Hardwood trees do not normally require brashing, as the dead lower branches are shed naturally ; it is necessary for all conifers though some, like European larch, require very little attention.

Brashing is carried out with a saw and the branches are taken off to a height of about seven feet ; the removal of a few live branches is usually unavoidable but this does no harm except to the spruces which are subject to attacks of canker.

Pruning, refers to the removal of branches to a considerably greater height than is involved in brashing. It is necessary for poplars and cricket-bat willows but with other species is carried out only in special cases, e.g., for telegraph poles or to improve the form of promising crops of hardwood species.

(v) **Thinning**.—Thinning must be carried out for the first time when the trees have begun to compete with each other for space and light and it should be repeated at intervals all through the life of the crop. The object of thinning is to favour the best trees and to improve gradually the quality of the stand as a whole.

There are various types of thinning described in the text-books but the type most commonly employed in this country is the "low" thinning in which attention is directed chiefly to the removal of trees falling behind in the race for dominance. Badly shaped trees of all sizes, including dominants, are also removed.

Fast growing species like Sitka spruce and Japanese larch may need thinning fifteen years after planting ; for slower growing species like Scots pine thinning need not usually begin until the trees are almost twenty-five years old. No rules, however, can be laid down for rate of growth varies from site to site, but whenever a crop has reached a height of about 25 feet it should be carefully examined to see whether thinning is necessary. Thinnings may be light, medium or heavy. For some light-demanding species heavy thinning is essential—an example is larch—while in an extreme light-demander like poplar, the crowns must not be allowed to crowd each other even slightly.

The interval at which thinnings should be carried out varies with the rate of growth. For the first few thinnings, three year intervals are necessary for Sitka spruce, Japanese larch and poplar. For most other species, five-yearly intervals are sufficient.

Thinning should be repeated in young and middle-aged crops, when the crop has made another ten feet of height growth. As the trees grow older, the intervals between thinnings may be extended.

Thinnings give useful returns in the shape of poles and other produce and, later on, of sawing timber. It should always be possible to utilise these at home or to dispose of them to a customer.

(vi) **Maintenance of Drains**—Drains must be maintained throughout the life of the crop and accumulations of stagnant water should be prevented. Neglected drainage is the principal cause of wind-blow and storm damage in woodlands.

(vii) **Maintenance of Fences**—Plantations must be securely fenced against rabbits until the trees have reached pole size, and if the plantations are hardwood, the protection must be maintained throughout the greater part of the life of the crop as severe damage may be caused to large hardwoods by rabbits in hard weather in the winter. It is cheaper to get rid of the rabbits.

Fences as a protection against cattle or sheep are not necessary after the first thinning, if physical damage to the tree is all that is being guarded against. Horses, however, may do serious damage to trees by gnawing the bark and killing the cambium.

Grazing in Plantations—Grazing should not be permitted in young plantations since sheep and cattle damage young trees. The temptation to turn stock into growing plantations is possibly greatest whenever there are plantations on hill ground as the cessation of burning and the fencing out of grazing animals often leads to striking changes in the herbage. Hill sheep grazing in young spruce plantations in early summer pay little attention to the trees at first and confine themselves to the grass on the rides and among the trees. Towards the end of July, however, they tend to leave the grass and begin to attack the young trees causing much damage in consequence.

Later, when the trees have reached pole size and are about twenty feet in height, they are proof against damage from cattle and sheep. Normally little grazing is to be had in hardwood plantations but larch and old pine woods on hill ground often provide a moderate amount. Foresters in general are averse to grazing because of its injurious effects on the growth of the trees and the condition of the forest floor. The loss of nutrients due to the consumption of herbage by the animals may have appreciable effects on soils of low fertility whilst the compacting effect of the hooves of the animals may be harmful. The development of natural seedlings in older woodlands is effectively stopped by sheep and cattle.

Nevertheless, it is possible that on soils of fair fertility, a certain amount of grazing may be carried on without lasting injury to the forest crop provided the stock are not too numerous and are admitted for limited periods.

FELLING OF TIMBER—LICENSING—Timber, generally, may not be felled except under licence, which is issued by the Forestry Commission. Under the Control of Growing Trees, (Felling and Selling) Order, S.I. 1950, No. 1, no growing tree, of more than three inches diameter at five feet from the ground, may be felled without a licence which must be obtained by the owner of the trees from the Forestry Commission.

There are the following exceptions :—

(*a*) orchard trees are not subject to the order.

(*b*) if the quantity of timber is small, not more than 275 cubic feet, quarter-girth Hoppus measure, over bark, in any one calendar month, no licence is necessary.

Any owner of standing timber who intends to fell it, or to sell it for felling, should first make an estimate of the quantity concerned. If this is in excess of 275 cubic feet, an application should be made for a licence to fell to the Conservator of Forests for the district in which the timber is growing. An owner of standing trees should not enter into negotiations for their sale until he has made certain that a licence to fell will be issued.

SELLING TIMBER—An owner should first make it clear to intending purchasers what he is selling. Difficulties frequently arise in practice through neglect of this elementary precaution.

Sales of standing timber may consist of (*a*) whole woods, (*b*) parts of woods or (*c*) individual trees. If a whole wood is being sold it should be marked clearly on an Ordnance Survey map ; if part of a wood only is to be sold, it should be clearly demarcated in some unmistakable way, i.e., by painting the boundary trees, so that the purchaser has no excuse for going beyond the limits of his purchase ; where individual trees are being sold, each should be marked distinctly. Any markings, either of individual trees or of boundaries should be described in the Sale Contract.

The vendor must afford reasonable facilities for the extraction of the timber and any extraction routes which he is prepared to give should be clearly indicated on a map or plan. This is particularly important in agricultural districts where timber from hedgerows and small spinneys and copses has often to be taken out across fields.

Agreement in advance about extraction routes may save much argument later.

It is also advisable to agree, in advance, about the time within which the operation should be concluded. The felling licence is valid only for a stated period and the work should be arranged for completion within the licence period.

Sales may be made (*a*) by auction (*b*) by tender or (*c*) by private bargain. Auction sales are a recognised way of disposing of underwood and coppice in some parts of the country while several well-known estates hold periodical auction sales of standing timber. When supplies are scanty and prices rising, to sell by auction may give the best return but against this is the chance of having on the ground a firm about which little is known and whose methods of working may not be satisfactory

Sales by tender, after advertisement, throw the lots open to competition and allow the vendor some choice in the selection of the purchaser. Both these methods *and the previous one* put the vendor to the expense of advertising or paying auctioneers fees and for small sales these are scarcely justifiable.

The commonest method, especially for small lots of timber, is for sale by private bargain and when dealing with a well-known timber merchant this is probably best.

It is advisable to obtain a valuation of the timber before it is offered for sale. Many sales of timber and especially small sales, are carried through with the owner in ignorance of the real value of the material offered. This often leads to difficulty in negotiating a sale and usually results in the vendor feeling he has made a bad bargain, no matter how good the price. A valuer's fee is usually recovered by the improved price realised

During the war of 1939-45 and for some years afterwards, the prices of standing timber were subject to control and maximum prices were laid down for all classes of home-grown timber. These restrictions have now been removed.

Timber may also be sold after it has been felled and sales of this kind are usually made on the basis of a price per cubic foot, the trees being measured when they are sold. The vendor makes the usual allowances for bark and for defects. This method is often used when an owner takes down his own trees to avoid damage to buildings or to other growth. There is no doubt about the volume measurement by this method, but it exposes any defects which may exist in the timber.

USES OF TIMBER

Oak—Strong, hard and usually straight grained. The heartwood is durable but the sapwood readily decays and should not be used where durability is an important requirement. Oak is difficult to season and is usually air-dried for prolonged periods before kilning and manufacture. Oak is used for gates, fencing, cartwright's and wheelwright's work, furniture, ship-building, railway wagons, house and building construction, coffin boards, turnery and cooperage.

Oak should not be used in contact with iron which it rapidly rodes. Seasoned oak timber weighs about 45 lb. per cubic t.

Beech—Strong, hard and usually straight grained. It is not rable and decays more rapidly than most British hardwood ibers; it is therefore unsuitable for outdoor work unless ated with a preservative. Beech, unlike oak, is easily spoiled eft lying after felling and it should be converted as soon as ssible after cutting. It lends itself to turning, and to bending er steaming.

Beech is used for turning into tool handles, bowls, rollers, ., for brush backs, heels of shoes, planes and mallets, for air making, toys and flooring.

It weighs about 45 lb. per cubic foot

Ash—Tough elastic and moderately durable. It seasons oderately rapidly in the air. Because of its toughness and ength, English ash is highly suitable for sports goods and table logs command good prices for this purpose. The ncipal uses are:—tennis rackets, hockey sticks, agricultural plements, furniture, tool, axe and pick handles, car and lorry dles, cart shafts, wheel felloes. It is also used in turnery and some extent in aircraft construction. Small poles and ppice shoots of ash are used for hurdles, crate-rods, walking cks, and hedge-stakes and rails.

When seasoned, ash weighs from 40–45 lb. per cubic foot.

Sycamore—Strong, moderately hard and even textured with a ht lustrous colour. It is not durable and is liable to become ined and discoloured before fully seasoned. It works oderately well but does not split. It is used for veneers and nery in which rollers, bobbins are made; it is also used in the anufacture of bread platters, and wooden household and dairy ensils, where its light colour is an advantage. At the present ne it is much in demand for furniture.

Sycamore coppice shoots, if too small for turnery are of little lue.

The timber weighs about 40 lb. per cubic foot.

Elm—The different species of elm produce similar timber. m is tough and strong but twisted in the grain and therefore ficult to split and subject to warping when sawn. In this spect, Wych elm is rather better than the common English n. The timber is only moderately durable in the open but when mpletely immersed in water it lasts a long time and for this ason has been used for piling and, in former times, for underound water and drain-pipes. Elm is extensively used for coffin ards and for the ends of boxes and containers. It is also used r the keels of boats, for naves of wheels, wheelbarrows and weather boarding while its use for the seats of chairs is known.

Elm weighs about 35 lb. per cubic foot when seasoned.

Birch—Birch is tough and fairly soft ; it seasons well bu not resistant to decay. It is suitable for cutting into plywood veneers and for turnery. It also bends well. Relatively li home-grown birch timber comes on the market but a consid able use is made of small branches and twigs.

Birch is used for chair-making, for the cheaper kind of tur articles, for brush backs, clothes pegs, barrel bungs, and c soles. It is also the principal wood used in the manufacture thread bobbins. Twigs and small branches less than an i in diameter are used in the steel rolling mills, for race cou jumps, and for besoms.

Birch timber weighs about 42 lb. per cubic foot.

Lime—This is not a strong timber, being soft and light, an not durable. It works extremely well and has long been one the principal timbers used in wood carving. The timber is u for the manufacture of dairy and kitchen utensils, for frames beehives, cabinet making and artificial limbs, while during war it was used in place of poplar by the makers of matches

Lime weighs when seasoned about 35 lb. per cubic foot.

Sweet chestnut—Large chestnut trees are usually badly sha in this country and it is often difficult to get much good tim out of them. Chestnut is rather less strong than oak but is h and extremely durable. It splits very easily, although many the older trees have a pronounced spiral grain.

The timber is used for purposes usually served by oak, e.g., gates and fencing, constructional beams, coffins, flooring, et

Young poles cut from coppice are used in large quantities split pole fencing. Hop poles are also obtained from chest coppice.

Chestnut timber weighs about 35 lb. per cubic foot w seasoned.

Alder—The timber is soft, light and easily worked but it is notable for strength. It is not available in large quantities in country. Alder timber is not durable above ground but wh used as piles or for under water work it shows great resistance decay. Alder is also the wood favoured for making clog-s which were once in great demand in the textile districts of Lan shire while, formerly, it was regarded as one of the best woods making charcoal for gunpowder. Alder is used extensively in manufacture of hat blocks and in turnery.

Alder wood weighs about 35 lb. per cubic foot when dry.

Walnut—Walnut timber is scarce in this country but it is of our most valuable woods and good logs always comma igh prices. The timber is strong, tough and hard, does not plit easily and is durable.

It is used mainly for furniture and in the manufacture of gun ocks.

Seasoned timber weighs about 40 lb. per cubic foot.

Poplar—Poplar is a soft light timber but strong and tough and ith a capacity for withstanding knocks and blows without enting or fracturing. The timber is not durable. It is light in olour, free from odour and straight grained. The different pecies of poplar vary slightly in the qualities of their timber but, the main, they conform to the above general description.

The Lombardy poplar is the only common poplar which is not sed for timber, chiefly owing to the large number of knots used by the numerous small side branches.

Poplar timber veneers readily and it is extensively used in the anufacture of matches and match boxes. It has also been used ccessfully in making pulp. The timber is admirably suited for rt bottoms, as it withstands knocks, while for chip baskets, cking cases, kegs and toys, it is used on a considerable scale. he timber of poplar, when dry, weighs about 28 lb. per cubic ot.

Willow—The timber of willow is generally similar to that of oplar. It is tough and light in weight (28 lb. per cubic foot) nd for this reason is frequently used in making artificial limbs. he other common uses are much the same as those of poplar nd it is readily taken for the manufacture of wood-pulp.

The cricket-bat willow is the source of the best bats although ferior and cheaper bats can often be made from other species of illow. For this purpose the timber must be fast grown, free om knots or stain, and straight-grained. The timber of the icket bat willow is light and very tough and does not split or plinter readily.

Hornbeam—The timber of hornbeam is not commonly met ith nowadays in this country but it has some useful qualities. is a dense wood which is difficult to split owing to twisted rain and it has the virtues of strength and toughness. It is not articularly durable. It is used for various purposes in which a ard wood is required, such as the manufacture of mallets. can be stained so as to resemble ebony.

When dry it weighs about 45 lb. per cubic foot.

Horse Chestnut—The timber is soft, light and neither partic-arly strong nor durable. It works and seasons easily and it n also be carved. It is white in colour. It is used in the manu-cture of domestic ware such as bread platters and kitchen ensils. It is also used for trays for fruit stores, and for boxes, ys and various articles of turnery.

It weighs about 30 lb. per cubic foot when seasoned.

Hazel—Hazel is not normally used for sawing or turnery owing to the small size of the coppice shoots which are available, but it has an extensive use for hurdles, hedge stakes, bean rods, pea sticks, thatch pegs and hoops for cooperage.

Scots pine—This is one of the most important timbers of commerce in Europe and is familiar to all as Baltic redwood. Grown in this country the timber is more variable in quality than that brought in from northern Europe, but the slow-grown Scots pine of north-eastern Scotland is as good as the best imported material. Moderately strong, tough and hard, this timber both seasons and works well. The heartwood is fairly durable, but the sapwood is liable to decay. It is used for a wide variety of purposes—in building construction, for railway sleepers, telegraph and transmission poles, pitprops and other mining timber, fencing, etc. It is extensively used in joinery and it can be cut into veneers for making chip baskets. When dry it weighs about 30–35 lb. per cubic foot.

Corsican pine—Relatively little Corsican pine timber has as yet come on the market in Great Britain so that its possibilities are not yet fully understood. Generally it is similar in qualities to Scots pine, except that it is slightly less strong and less durable, and it can be used for the same purposes. It has been proved to be very suitable for mining timber.

It is a little lighter in weight than Scots pine when seasoned.

European larch—This is one of the most valuable of our home-grown timbers, especially for farm and estate purposes. It is strong, tough and durable, but is less easy to season and work than Scots pine. The large timber is used in boat-building and for piling in harbour and dock works, while it is also used in farm buildings, for floors, weather boarding and other purposes. It is extensively used in fencing, particularly in the north where fence posts are cut from quartered larch, for straining and gate posts and, when of small dimensions, for net stakes, light fence posts and rustic work. Larch is also used extensively for pit props and other mining timber for which it usually commands a higher price than pine.

It weighs more than Scots pine—about 37 lb. per cubic foot.

Japanese larch—No mature timber of this species has yet become available in Great Britain though large numbers of poles are now available every year. These are put to the same uses as similar poles of European larch.

This timber is lighter in weight, softer, and possibly more brittle than that of the European species, but otherwise it appears to possess similar qualities.

It weighs 31 lb. per cubic foot when seasoned.

Douglas fir—This tree yields the familiar Oregon Pine timber of commerce. Grown in this country, it is usually wide ringed and knotty when young, becoming closer ringed when it gets older. It is a fairly strong timber, lighter than larch or Scots pine, hard but only moderately durable. It seasons readily, but does not work well, while it is apt to split when being nailed, unless this operation is carefully performed.

It has been used for railway sleepers, pit-props and other mining timber, for fencing and in boxes and packing cases.

It is about 31 lb. in weight per cubic foot when seasoned.

Norway spruce—Imported spruce from northern Europe is known as whitewood and has an extensive range of uses. The timber of home-grown spruce can be applied to the same purposes, as it compares well with the imported material save in respect of knottiness. It is a light, soft and moderately strong timber, tough and easy to work except when knotty. It seasons well, but is not durable. Sawn spruce is largely used in the construction of buildings, in box making and in the fittings of houses. It can also be cut into serviceable roofing shingles. In the form of poles it is used for ladder poles, scaffold poles and, when cross cut to length, as pit props. It is the principal timber used in the manufacture of paper pulp in Europe.

Seasoned timber of Norway spruce weighs over 27 lb. per cubic foot.

Sitka spruce—Home-grown supplies of this important timber are now coming forward from young plantations in increasing quantities. In appearance and qualities it is similar to, though slightly inferior to Norway spruce, but is usually wider-ringed owing to its faster growth. It is rather lighter than Norway spruce, as it weighs only 25 lb. per cubic foot.

Western Red Cedar (*Thuya plicata*)—The timber of this tree is renowned for durability in its main habitat in North America. The timber is light (25 lb. per cubic foot) but has no great strength. Home-grown *Thuya* has been little used in this country as supplies have been scanty but it has proved its value for fencing, for ladder poles and in one or two cases, for roofing shingles, a purpose for which it is extensively used in America.

Lawson's Cypress—The timber of this tree, like that of the Western Red Cedar, is not available in any quantity but it can be used for fencing as it is highly durable. It is heavier than *Thuya* (27–30 lb. per cubic foot) and stronger.

Western Hemlock—A moderately strong, but soft, and not very durable timber, is obtained from this species. It is slightly heavier than *Thuya* or Lawson's cypress weighing 30 lb. per cubic foot. Little experience has been acquired of the uses to which home-grown timber of this species may be put, but it ought to be suitable for purposes for which spruce is used. It i said to be well adapted for pulping.

Yew—The timber of this native species, though not availabl in any great size or in large quantities is of great value because o its durability. For gate posts or fence posts there is nothin better. The timber of Yew is hard, tough and fairly heav (42 lb. per cubic foot) and because of its rich colour and hand some appearance it is a valuable ornamental wood.

Preservative Treatment of Timber—Very few of our nativ timbers are durable when used out of doors and some o them are particularly subject to decay in such circumstances There are great advantages therefore in the use of a reliabl preservative ; it increases the life of moderately durabl material and it makes possible the use of timbers which coul not otherwise be employed at all. There are various chemical which can be employed in wood preservation but the commones and the most convenient in use, is creosote. It is readil available, moderately priced, and is toxic to wood-destroyin fungi.

Creosote may be painted over the timber with a brush applied by soaking the timbers in cold creosote, or by soakin the timber first in hot and then in cold creosote or finally it ma be applied under pressure.

The first method has little to recommend it. It is useless fo posts and other timbers which are in contact with the ground and although it can be used for weatherboarding and timbers used i similar ways, the applications must be repeated every few years

Steeping in cold creosote leads to the absorption by the timbe of sufficient quantities of the preservative to make it proo against wood-destroying fungi and injurious insects, but th rate of absorption is slow and the process may take sever weeks. This makes the method inconvenient in practice.

Creosoting under pressure is by far the most efficient metho but it requires special plant, the use of which can only b justified when large quantities of timber are being handled. is therefore unsuitable for the smaller owner of woodland When purchasing creosoted timbers for gates, fencing, ou buildings, etc., it is advisable to specify " pressure creosoted."

The most convenient method on a small property is the " h and cold " process in which the timbers are immersed in a tan of creosote which is then heated to a temperature just below th boiling point of water—to about 200° F. The creosote is ke at this temperature for about an hour and is then allowed t cool. The creosote is absorbed by the timber during the coolin process.

For this method of treatment a permanent tank may be bu large enough to handle the various types of material and it may be heated by a fire or by steam coils if a source of steam is available. But where the material to be treated is mainly fencing posts and when the quantities are small, a metal drum of about 100 gallon capacity can be used in place of a tank. This drum should be set up on a hearth of bricks which should be provided with a chimney to promote draught, and in it the creosote can be heated to the required temperature. The posts should be placed upright in the drum. It may save time if a second drum of the same size is placed nearby and filled with cold creosote and the posts may be transferred from the hot preservative to the cold after they have been treated for an hour. In this way, it is possible to handle a larger quantity of material.

The time taken to complete creosoting by the " hot and cold " process varies with the species. Beech, elm, sycamore, birch and alder which take creosote readily may not require more than three or four hours in the cooling creosote. Others, such as spruce and Douglas fir, may require a full day. In creosoting, it is usually considered satisfactory if ¾ gallon to one gallon per cubic foot of timber is taken in.

Before treatment posts should be peeled and all bark carefully removed. It is usually better to season them in the open air for several months before they are creosoted.

Pests and Diseases of Trees

(*a*) ANIMALS—**Deer** are a serious menace to plantations of all species by browsing on the young plants. Trees in the small pole stage are also severely damaged by rubbing. Certain species, e.g., silver firs, *Thuya* and *Pinus contorta*, are very susceptible. Deer are more numerous and widespread in this country than generally realised, the principal species at large being red deer, fallow deer and roe-deer with small numbers of other species such as the Japanese deer occurring locally.

Rabbits and Hares are important enemies of forest trees. The damage caused by rabbits is well known but hares can be equally destructive in young plantations. Hares frequently bite off the leading shoots of small trees but after this early stage they do little damage.

The **Red Squirrel,** a native woodland animal in Great Britain causes enormous damage at times in the pine woods of northern Scotland where it must be kept under.

The **Grey Squirrel,** an American species now naturalised, does most damage in the southern half of England. Unlike the red squirrel it does not seriously damage conifers but attacks the shoots and branches of many hardwood species. Sycamore is probably damaged more often than other trees but beech, horse-chestnut and ash are attacked, the dead tops and branches of the trees being evidence of the presence of squirrels. Any increas in the numbers of this animal would have grave consequences t English woodlands.

The Field Vole occasionally increases so rapidly in numbe as to become a plague. This usually happens on grassland, an where large areas have been enclosed for planting, the resultin increased growth of herbage gives these small animals the cov required. The voles attack and kill young trees by gnawi through the bark into the wood and many acres of plantatio have been destroyed in this way when the numbers are hig Little can be done to counter a plague of this character but su populations of voles have a habit of disappearing rapidly.

(*b*) **Birds**—Very little damage is done to trees by birds in th country. If numerous, blackgame may do serious injury t newly planted conifers by eating the buds. If these attacks a repeated the young trees cannot develop and grow normally.

(*c*) **Insects**—Severe outbreaks of insect damage on the sca met with in other countries, are uncommon in Great Brita although there are numerous insect pests of forest trees whic cause serious damage from time to time. Some of the mo important of these pests are listed below.

Oak-leaf roller moth (*Tortrix viridana*)—This insect is respo sible for the defoliation of oak trees which is widespread ov Britain in certain years. The caterpillars of this moth eat th leaves of the oak and may be present in such numbers as t strip the trees almost bare. The trees are not killed and i variably put out a fresh crop of leaves after the larvæ ha pupated, but the attacks cause a loss of increment and ma weaken the tree sufficiently to allow it to become the prey o other pests. The pedunculate oak is more susceptible than th sessile and in badly infested oakwoods individual sessile oa standing out green and full-foliaged among the leafless pedunc late oaks may sometimes be seen. Sawflies of different speci attack various trees, especially larch and pine, their larv consuming the needles. The large larch sawfly (*Lygaeonemat erichsonii*) caused great havoc in larch plantations in Wales a north-west England before the first world war.

The pine saw-fly (*Diprion pini*), in the larvæ stage, devou the needles of Scots pine but rarely does any lasting damage.

The foliage of several conifers is attacked by various aphi which may cause leaf shedding leading to slow growth. Th spruce aphis (*Neomyzaphis abietina*) which, for the last fe years, has been causing extensive damage to Sitka spruce in parts of the country is an example. Few trees have died consequence, but large numbers have been very badly defoliate

On the Douglas fir, the insect known as *Adelges cooleyi.*
tacks the needles. This insect, when present in large numbers,
es not kill the tree but has the effect of reducing its rate of
owth. *Adelges* covers itself with a white woolly substance and
en in this condition is conspicuous on the needles.

The felted beech-coccus (*Cryptococcus fagi*) sometimes
curs in abundance on the bark of beech trees forming a
aracteristic white felty mass. The insect mostly attacks trees
ich are in an unhealthy condition.

Bark-beetles of the family *Scolytidae* attack a large number of
ees, both conifer and hardwood. They usually select sickly,
ing or recently dead trees for breeding purposes and their
ood galleries form characteristic markings under the bark of
fected trees. Generally, bark beetles need not cause serious
ouble if care is taken to see that sickly or dead trees are not
ft standing in plantations or hedgerows and that felled timber
not left lying with the bark on especially in the spring and
mmer. One of the bark beetles which breeds on elm is the
rrier of the Dutch Elm Disease.

The Pine weevils (*Hyblobius* and *pissodes*) are very troublesome
sts and cause serious damage to newly formed coniferous
antations. These weevils gnaw the bark of young trees which
girdled are killed. They breed in the stumps of felled conifers
d continue to do so until the stumps are too old and dry to be
tractive ; if weevils are present, it is advisable, therefore, to
lay the replanting of coniferous woodland until the stumps no
nger serve the weevils as breeding sites. This means, as a rule,
wait of at least three years.

Dutch Elm Disease, caused by the fungus *Graphium ulmi* has
en present in the country for more than twenty years and has
read widely from eastern England where it was first discovered.
attacks all the common elms and causes a die-back of the
oots and branches and sometimes of the whole tree. It reveals
elf by the wilting and withering of leaves and shoots in the
mmer and infected twigs and branches when cut open show
pical black streaks in the woody tissues. As the spores of the
ngus are mainly spread by the elm bark beetle (*Scolytus*
structor) measures to control the numbers and spread of this
sect help to control the disease.

Watermark Disease of Cricket Bat Willow is a serious disease
this valuable tree. Caused by a bacterium it is characterised by a
ack stain in the wood which makes it useless for cricket bats.
ffected trees are recognised by the wilting of the branches in
rly summer and sometimes by an exudation of slime from the
seased parts. Diseased trees should be cut down and destroyed
d in Essex and some neighbouring counties an order is in force
aking the destruction of diseased trees obligatory.

Honey fungus (*Armillarea mellea*) is widespread in occurren
but is probably commonest in old hardwood woodlands and
areas of birch scrub. Conifers which are planted on those sit
are often severely attacked and damage has also been caused
fruit trees in orchards on ground which was formerly o
woodland. The attacks are usually fatal. This fungus produc
groups of dirty yellow fructifications at the base of affect
trees. These produce the spores, but *Armillarea* has anoth
means of spreading, namely, by long strands of mycelial tiss
called rhizomorphs and resembling to some extent bootlace
These spread from affected to healthy trees eventually killi
them. A characteristic feature of this disease is the presen
of the rhizomorphs under the bark of dead trees.

Fomes annosus is a very common fungus responsible for t
death of young trees and, more important, for much of the bu
rot which occurs in conifers and which causes a great loss
timber annually. This fungus is recognised by its fructificatio
tough and leathery, greyish brown above and white and poro
beneath, found on the stem and roots about ground level.
spreads by spores which germinate on the stumps of felled tree
this fungus passes subterraneously into the roots of healthy tre
which are in contact with the affected roots.

Larch canker caused by the fungus *Dasycypha calycina* is
serious disease of European larch which causes cankers on t
stem. It is most severe on frosty sites and in areas where the
does not circulate freely. Although few trees are killed by th
fungus, it is always present as one of the complex of pests a
diseases which cause the serious " die-back " of this species.

Diseases and Pests. Legislation—Under the Importatio
of Forest Trees (Prohibition) Orders (England and Scotlan
of 1949, the import of living plants of the following tr
genera is prohibited :—

Castanea, Abies, Larix, Picea, Pinus, Pseudotsuga, Sequo
Thuja, Tsuga, Populus.

The import of elms (*Ulmus*), which was formerly prohibite
is now allowed.

Import of poplar (*Populus*) is allowed under a licence issued
the Ministry of Agriculture.

The object of these orders is to prevent the introduction
dangerous insect pests and fungi and other diseases into t
country.

The Watermark Disease (Essex) Order of 1938 gives the lo
authority power to serve notice upon the owner of willow tr
affected by the Watermark Disease to take action to remove t
infected trees. The local authority may insist on the felling

diseased trees, the destruction of the trunks or the branches by fire or the removal of bark from the branches.

Similar orders affecting the County of Suffolk, parts of Hertfordshire and parts of Middlesex were issued in 1948.

Grants for Planting and Maintenance—(*a*) **Dedicated Woodlands**—Under the Dedication Scheme, financial assistance is given to owners who have dedicated their woodlands. Payments are made on one of two bases, at the option of the owner, as follows :—

Basis I—Repayment to the owner of 25 per cent. of the approved nett annual expenditure on the dedicated woodlands. Loans are also available. See Loans below.

Basis II—Payments to the owner as follows, in respect of dedication agreements entered into after 30th September, 1949 :

1. A Planting Grant of £12 per acre for every acre planted or replanted, after the date of dedication, whether hardwoods or softwoods.
2. Loans in addition to I, up to an amount to be fixed with reference to individual circumstances, to be made available on the terms stated below.
3. A Maintenance Grant for 15 years of four shillings per acre per annum on every acre dedicated that is thereafter planted and properly maintained.
4. A Maintenance Grant for 15 years of four shillings per acre per annum from the date of dedication, on all productive woodland other than new plantations (which are already covered by 3 above).
5. These grants will be reviewed, and revised as necessary after five years from 1946–47, on the basis of ascertained costs.

(*b*) **Woodland unsuitable for Dedication**

For other woods which are not considered suitable for dedication, planting grants at the rate of £12 per acre are available on the understanding that the timber may be felled in an emergency of national importance. This figure is subject to periodic revision. No maintenance grants are payable for woods of this character.

Loans—The Forestry Commission is prepared, subject to satisfactory security, to make loans to owners of dedicated woodlands to cover a substantial part of the costs of replanting. The rate of interest depends on the Government borrowing rate ruling when the loan is made but under present conditions this is 3 per cent. Payment of interest to be made annually, the first payment becoming due twelve months after the loan is made. The repayment of the capital by annual instalments need not begin until the 16th year but in all cases repayment is to be completed within 50 years from the original date of the loan.

The security will normally be the dedicated woodlands, which for this purpose require to be insured against fire, but in some cases collateral security may be necessary.

Other Grants.

Poplar—Grants for planting poplar are now available from the Forestry Commission.

An owner of suitable land may obtain grants of two kinds.

(*a*) For planting in blocks, a grant of £8 per acre, provided that the area is not less than two acres, and provided that the plants are put out at not more than 24 feet apart and not less than 16 feet.

(*b*) For planting in lines or avenues, a grant of £10 for each hundred trees, or two shillings a tree, provided that the trees are not less than 18 feet apart and that at least 200 trees have been planted on the owner's property in any one year.

For both grants, the planting of approved disease-resistant varieties or species is an essential condition.

Hill Farming Act, 1946—The planting of shelter-belts is one of the improvements which may be included in schemes for rehabilitation of hill farming land under this Act. Within the limits of the aggregate sum made available for this purpose, improvement grants of one half of the cost of the work are made for approved schemes.

These grants are administered in England and Wales by the Ministry of Agriculture and, in Scotland, by the Secretary of State.

Thinning Grants—In order to encourage production, particularly of round mining timber, from British woodlands, the Forestry Commissioners are now offering grants for thinning to owners of plantations. These grants may be paid in one or other of the following forms.

1. (For conifers only)—Threepence per cubic foot is paid for timber removed in thinnings, measured to a 2½ inch top diameter under bark, provided that there is a yield of at least 150 cubic feet per acre. For this grant, the owner must keep an accurate count of the number of poles which are cut and must make detailed measurements of a proportion of the thinnings.

2. This grant which is available for broadleaved or hardwood trees, as well as for conifers, is paid at the rate of £3 15s. 0d. per acre. As for the first grant, there must be a minimum cut of 150 cubic feet per acre, measured to a 2½ inch top diameter in conifers and a 3 inch top diameter in hardwoods, but hardwood trees more than eight inches quarter-girth at breast-height must be excluded from the count.

Income Tax and Death Duties on Woodland.

Income Tax—Owners of woodland are normally assessed to Income Tax under Schedule A as regards ownership and under

Schedule B as regards occupation, but any person occupying woodlands may elect to be assessed under Schedule D instead of Schedule B if he can satisfy the Commissioners of Inland Revenue that he is managing the woodlands on a commercial basis and with a view to the realisation of profits.

This election to be assessed under Schedule D is binding during the lifetime of the person who makes the election ; that is, having once put his woodlands under Schedule D, he cannot revert to Schedule B, although his successor may be able to effect the change. Further, the election must extend to all woodlands on the same estate similarly managed on a commercial basis, with the exception of woodlands planted or replanted since 19th July, 1916, which may be regarded as woodlands on a separate estate on notice being given to the Commissioners within ten years of the planting or replanting.

Thus an owner who is managing his woodlands may place his young woodlands under Schedule D and his older woods under Schedule B and in this way is able to benefit substantially. Schedule D is a tax not on occupation but on profits and under this Schedule losses may be shown as well as profits. In the early years of a plantation expenditure on its formation and maintenance is always much greater than receipts so a loss is inevitable ; if these woods are assessed under Schedule D, the amount of the loss may be set off against other income and the owner may obtain a repayment of tax on a sum equal to the loss. Under Schedule D, accounts must be kept.

Death Duties—The value of standing timber, coppice and underwood is not taken into account when valuing an estate for Estate Duty. The rate of duty payable is based on the value of the property less the standing woodlands.

Estate Duty is paid on timber at the rate appropriate to the estate, only when the timber is cut ; it is not payable on underwood.

The same concessions apply to Succession Duty, but under the Finance Act, 1949, no succession duty is payable in the case of sales of timber which take place on or after 30th July, 1949.

Hedges—The principal hedging plant in agricultural districts is the thorn (*Crataegus monogyna*) which is serviceable, strong and, if correctly managed, long-lived. It is not easily damaged by stock.

Beech is also used extensively for hedging. It makes a strong hedge, moderately easy to keep in order, and since it retains most of its dead leaves in winter additional shelter is obtained.

Hornbeam is a useful hedging tree, forming a slightly weaker hedge than beech but with the advantage of growing in frosty sites where beech is apt to be damaged severely. It grows at about the same rate as beech.

Among evergreen trees, holly is frequently used and makes an admirable hedge which can be grown to a considerable height Trimming a holly hedge is hard work, owing to the toughness of the shoots and the prickly character of the leaves, and holly hedges to some extent have fallen into disfavour on this account

The yew is still used for hedging in gardens where it forms a pleasant, durable hedge which lends itself readily to clipping and shaping. It *cannot be used* where stock have access to it as its foliage is poisonous.

Cupressus macrocarpa, the Monterey Cypress is an evergreen tree which can be used for hedges in the south and south-west of England. It is useful in places which are exposed to the sea as it grows rapidly and stands up well to exposure to sea-winds. A useful shelter for a garden can be obtained readily by the use of this tree, but it is untidy in habit and should not be used where appearance counts.

The Lawson's Cypress—*Chamaecyparis Lawsoniana* can be used in any part of the country and, although slower in growth gives a much tidier and more ornamental hedge than the macrocarpa.

Scots pine has been used in the past as a hedge and windbreak in the dry, sandy areas of East Anglia. It forms a moderately good hedge but is apt to become bare at the bottom and generally untidy ; where local conditions do not favour the more common hedging species it can be useful.

On very poor acid soils, where it is difficult to establish most tree species, broom and gorse or whin have been used at various times as hedging plants. They grow rapidly but are good fo only about seven or eight years, while they are liable to be damaged by snow or killed outright in severe winters. Nevertheless they can be made to grow where it is almost impossible to grow anything else. For this purpose, these species are bes raised by sowing the seed along the line of the proposed hedge and an application of a phosphatic fertiliser at the time of sowing helps to stimulate growth. Germination is improved by pouring hot water over the seed about twelve hours before sowing an allowing it to soak overnight.

Hedgerow Timber—A considerable part of the total quantity of hardwood timber in England is composed of trees growing individually in hedgerows and though little new plantin of hedgerow trees is now carried out, the remaining quantities are so large and their importance as a stock of hardwood, so important, that more attention should be paid to their management The three main species are elm, oak and ash, for although othe species are not infrequently represented in hedgerows their importance is relatively small.

English elm, which is characteristic of so much of midland and southern England, does not normally produce fertile seed in this country and propagates itself vegetatively by means of root suckers. This is a great advantage and it is quite common in an old elm hedgerow to find trees of all sizes, from young thrusting saplings to large mature trees. The young trees. seldom receive any attention or encouragement to develop. By judicious felling of mature trees and by preventing damage to the young stems, the owners of elm hedgerows can maintain without much difficulty, a succession of timber-producing trees. Damage may be caused by the elm disease, but the risk of this can be reduced by attention to " sanitary " measures as already indicated.

Although oak and ash produce strong coppice shoots after they have been felled, these shoots are rarely satisfactory as a means of producing new trees and if these trees are to be perpetuated as hedgerow timber, it is best to replant.

In planting hedgerow trees, it is advisable to use large plants, preferably five or six feet in height, which are expensive as they have to be specially grown. The trees must be carefully planted in pits and they should be staked in order to prevent damage by wind.

If within reach of stock the young trees must be given a simple tree-guard and they should be protected by a ring of netting placed round the guard, if rabbits are present. The trees should require little further attention.

Much loss is caused by the all too common practice of using hedgerow trees as fence and gate posts, in which wire, netting and gate-irons are affixed to the trees. The growth of the tree leads to the inclusion of these articles within the stem and causes serious damage later on in the saw-mill when the trees are being converted. Damage to saws and other machines by iron incorporated in the timber is an expensive matter for the sawmiller.

The risk of finding iron in the butt-lengths of hedgerow timber is so well known that a timber merchant must make allowance for it when he is buying hedgerow trees. In the aggregate, the loss to the growers of the trees is a substantial one, which could be avoided by treating the trees, whilst growing, with the same care other crops receive.

Removal of Stumps—The removal of stumps of trees is often necessary where they are situated in ground which is required for building or other purposes. If the need for the removal of the stumps can be foreseen at the time the trees are being taken down, then they may be disposed of in two different ways.

(*a*) If, at the time of felling, the trees are cut off at about a foot above ground level, a bulldozer may be used to extract the roots from the soil. This method cannot be used so successfully if the trees are cut flush with the ground.

(*b*) The whole tree, instead of being felled, may be grubbed up, root and all, either with the Monkey Winch or with a tractor fitted with a Winch. A caterpillar tractor is better than a wheeled tractor for large trees. When this has been done, the root can be severed from the stem with a saw.

Where the trees have already been felled and only the stumps are left, the following methods can be used.

(*a*) By manual labour with picks, etc. This is effective but slow and expensive. Nevertheless it is often the cheapest way if there is only one stump to remove. Operations may be eased considerably with the aid of a timber jack.

(*b*) With explosives.

Where there is no risk of danger to houses, buildings, etc., explosives are a convenient means for removing stumps having the great advantage over other methods of shattering the stumps which simplifies the disposal after extraction. This is a great objection to the other methods because the disposal of a large number of tree roots is a formidable and expensive undertaking.

Gelignite is commonly used for this purpose. Charges are placed below the stump to blow it out of the ground and it is advisable to insert another charge in a boring made with an auger in the stump itself to shatter both stump and root. One pound of gelignite is usually employed for every foot in diamete of the stump.

The Killing of Trees—Various methods have been devised for killing unwanted trees. Among these may be mentioned:—

(*a*) **Girdling and Ringing**—By removing with an axe complete ring of bark and cambium round the stem just above ground level a tree may be killed in a relatively short time. Bu if this is not effectively done, the tree may survive; if it is vigorous tree callus may be formed on part of the cut sufficien to enable it to remain alive. Many hardwood trees, thoug they die above the girdle, survive below and throw out numerou stool shoots.

(*b*) **Poisoning**—Numerous substances have been used fo poisoning trees, including creosote, paraffin, carbolic acid sodium chlorate, calcium chlorate, copper sulphate, etc. Th most consistently satisfactory, however, are the compounds o arsenic. Common white arsenic at the rate of one pound or tw pounds of arsenic to one gallon of water is said to be effectiv on trees of most species, and one quart will kill a tree 4 feet i diameter.

The poisons can be applied either to a girdle cut in the tree as escribed in (*a*) above, or poured into holes bored into the ump with an auger. The former is said to be more effective. lthough arsenic is the most effective poison which has been sed in the past it is extremely dangerous and in many situations is safer to use one of the other substances.

Recent work in America has shown that ammonium sulpha- ate is effective in killing trees when applied in powder form to uts made at the base of the stem. This chemical is not yet made Great Britain and is still very expensive.

To kill sprouting stumps left after trees have been felled, senic may also be used but sodium chlorate in solution 0 per cent.) has been found to be effective in North America hen sprayed on stumps.

Poisonous Trees—None of the common timber trees this country is poisonous to human beings or to stock and the nly tree likely to be met with in woodlands which is poisonous, the common yew. The foliage, shoots and seeds contain a oisonous principle which often causes illness and even death mong cattle which have browsed on it. The effects of the oison seem to vary in different cases and cattle have been nown to consume branches and leaves of yew without taking arm. Nevertheless, yew should not be planted when it is open access by cattle and it should be removed from the edges of oods surrounded by pasture. Woods which contain numbers f yew trees should not be opened to stock.

Christmas Trees—In Great Britain the tree which is lmost exclusively demanded for this purpose is the Norway pruce. It may be sold either as an unrooted top or a young ooted tree. This useful, though seasonal and limited market, an be supplied very successfully by smaller growers.

Tops are usually taken from thinnings and any thinning in orway spruce which can be carried out in December yields a seful return if the best of the tops are severed from the felled ees and set aside for the Christmas tree market. Most of the rger Christmas trees are obtained in this way.

Rooted trees may be supplied from plantations specially rmed for this purpose, or they may be produced in another ay. If when forming a plantation of Norway spruce, the plants re set out at double the normal density, e.g., at 3 ft. by 3 ft., will be possible after a few years to lift alternate trees for sale Christmas and leave the remainder spaced at 6 ft. apart, to row on to form the crop.

Christmas trees, to obtain the best prices, should have a rich een colour, a symmetrical shape and ample foliage.

Protection from Fire—Fire is one of the principal emies of the planter and it can undo, in a few minutes, years of work. The risk of fire in plantations which are surrounde by arable land is not high, unless they are bordered by a bus main road or an important railway line, but on moorland ar hill land the risk is higher and is possibly highest on the dr low-lying heather land in the south and south-east of Englan

There are two periods of maximum risk. The worst is in th late winter and early spring when the ground is still covered wi a mass of dead vegetation ; at this season a spell of dry weath accompanied by a strong wind makes the whole surface extreme inflammable. The other period of high risk is in the secor half of the summer when long spells of dry weather and hig temperatures are sometimes experienced and the risk at th season is increased by the presence in country districts of larg numbers of holiday-makers.

Large blocks of plantations such as are found in the ne State Forests, have their own particular problems in fire pr tection which require special measures to solve. The priva owner and especially the small owner of woodland has no nee of elaborate precautionary methods but should always b prepared to defend woodland from fire. One or two precautior can be taken. In the first place, it is advisable to have ready each plantation a small number of birch-brooms, such as a used in State Forests, for use in beating out fires in the herbag These brooms which are made from birch-twigs like an ordina besom, are highly effective and can be made cheaply at any tin when work on the land is at a standstill owing to frost or hea rain. Secondly, arrangements should be made, before the fi starts, for calling on neighbours and, if necessary, the Fi Service for assistance. Thirdly, any particularly dangero places round the boundaries of the plantation should be attend to before the risk of fire becomes acute. Patches of de bracken can be raked away, for example, and clumps of i flammable gorse and broom cut down and removed, if th occur on the edge of a plantation where it adjoins a railw or a main road. Work of this kind can also be carried out hard weather.

Needless to say, great care should be exercised in the condu of heather or moor-burning in order to avoid damage plantations.

Firewood—The value of different timbers for fuel vari considerably according to the species and whether the wood heart wood or sapwood and whether the logs are green or dry.

Among the hardwoods, ash and possibly trees like app pear and hawthorn, may be used either green or dry bu generally it is advisable to allow the logs to season befo using them. The commoner hardwoods may be classified follows in respect of their serviceability as fuel woods.

Good quality—Ash, Beech, Oak, Hornbeam, Apple, Pear, Thorn.

Moderate to good quality—Elm, Birch, Sycamore.

Poor quality—Spanish chestnut, Willow, Poplar, Lime, Horse-chestnut.

Spanish chestnut, which is sometimes passed off as oak on the unwary, is a very poor fuel wood and does little more than smoulder. It splits very easily but is of little use for kindling.

Among the conifers, only yew and the heart wood of old Scots pine compare with the hardwoods. Most of the others burn away quickly, although giving out a fair heat, but some species such as larch and spruce are liable to spark badly and damage rugs and carpets. Conifers ignite quickly, especially the more resinous, and as they split well they are very useful for kindling.

AGRICULTURAL LEGISLATION

AGRICULTURE ACT, 1947, AND AGRICULTURAL HOLDINGS ACT, 1948

Until the 1939–45 war the agricultural system of this country was based upon the relation of landlord and tenant. Under the Agriculture Act, 1947, the State was introduced as an active partner, concerned with both the management and farming of agricultural land. This Act is not a declaration of Government policy, but the means by which a comprehensive agricultural policy, supported in its main principle by the major political parties, can be carried into effect. The Agricultural Holdings Act, 1948, was a consolidating measure ; and, without altering the law, collected into one statute the provisions of Part III of the 1947 Act and the surviving provisions of the Agricultural Holdings Act, 1923. Accordingly, in general, the law relating to landlord and tenant of an agricultural holding is found in the Agricultural Holdings Act, 1948, but otherwise the 1947 Act remains in full force.

The Agriculture Act, 1947, composed of five Parts, is often said to rest upon "twin pillars" of stability and efficiency. Part I of the Act purports to provide the necessary stability by giving guarantees of price and market. The efficiency provisions are contained in Part II, dealing with good estate management and good husbandry. Part III of the Act (now embodied in the Agricultural Holdings Act, 1948) deals as above mentioned with the law relating to landlord and tenant. Part IV establishes in statutory form the framework for the smallholdings policy of the Government and Part V makes provision for the necessary administrative machinery.

Guaranteed Prices and Assured Markets (Part I)—Part I of the Act was brought into force by Order in Council on 31st March, 1948, and applies not only to England and Wales but also to Scotland and Northern Ireland. The provisions establish in permanent form a system of regular consultation between the Government and representatives of producers which was begun during the 1939–45 war, the object being to fix prices and quantities of agricultural produce which the Government would purchase.

Every February a review is held investigating the general economic condition and prospects of the industry ; a special review may take place whenever this is rendered necessary by reason of a sudden and substantial change in the costs of the industry. At the annual review prices and conditions are fixed relating to—

(*a*) the scheduled crops to be harvested in the calendar yea following that in which the review is held : and

(*b*) fatstock, milk and eggs for the period of one year immediately following the review.

There is also provision for the fixing of minimum (as wel as actual) prices, the net result being that actual prices and conditions are known one year ahead and minimum prices and conditions for not less than two nor more than four years ahead.

To take an example, the annual review in February, 1954, dealt with—

(*a*) Prices and conditions for wheat, barley, oats, rye, potatoes and sugar beet to be harvested between 1st July, 1955, and 30th June, 1956.

(*b*) Prices and conditions for fatstock, milk and eggs for the 12 months ending February, 1955.

(*c*) Minimum terms for fatstock, milk and eggs for the period 1956 to 1958.

The system applies only to the products set out in the First Schedule of the Act which represent over 70 per cent. by value of all the produce sold off farms in the year. The Schedule at present omits, however, a number of important commodities such as the valuable horticultural group, seeds and table poultry Wool was omitted from the First Schedule when the Act was originally passed, but provision is made by the Act for additions to the First Schedule and wool was accordingly added by Order in Council to the "review commodities" during 1950

The price, under the Act, may be a guaranteed fixed price, a rate of deficiency payment related to a standard price, an acreage payment, and so on ; and wherever a price is fixed in respect of a given commodity, that decision must be taken in the light of the results of the annual and special reviews conducted between the Government and the industry.

The subject of quantity must also be dealt with at the annua and special reviews for the producer to know at the time prices are fixed what volume of production is so guaranteed. In this connection it is made clear by the first section of the Act that the guarantee applies only to "such part of the nation's food and other agricultural produce as in the national interest it is desirable to produce in the United Kingdom." This depends upon the decision of the Government of the day. However the Minister of Agriculture announced in June, 1947, that the Government was prepared, for as far ahead as could be reasonably seen, to accept complete liability for assuring a

arket for the whole output of the guaranteed price com-
odities subject only to reservations in respect of sugar beet
nd oats. Subsequently, in December, 1947, the Secretary of
ate for Scotland gave on behalf of the Government an under-
king to accept complete liability for assuring a market for the
hole output of oats for the United Kingdom up to and including
e 1951 crop. With respect to sugar beet the determining
ctor is the capacity of the factories and expansion of factory
ipacity in turn depends upon Government policy on the sugar
dustry generally at home and overseas.

The procedure at the annual and special reviews follows
he system established during the war of 1939–45, but with
nprovements made in the light of experience. The reviews
re largely based on statistical information gathered by
overnment and producers' organizations. This information
lls into three main groups—(*a*) farming income; (*b*) trends of
rofitability in different types of farming, based upon statistics
btained by the Farm Management Survey and the N.F.U.
arm Accounts Scheme; and (*c*) "costs structures" showing
he proportion and total costs of production relating to each
em, such as wages, fertilizers and so on.

Once prices and conditions are fixed for the "guaranteed"
ommodities, for the period under review, the question arises
ow, and to whom, those commodities are to be sold. Pending
nal decision on the functions and duties of a Ministry of Food,
and when established by Statute, and a precise declaration
f Government policy towards producers' marketing schemes,
he provisions of section 4 of the 1947 Act will operate. This
ection enables the Agricultural Ministers and Minister of Food
o make any arrangements necessary to achieve the purpose
f Part I of the Act, including the purchase of scheduled
ommodities by the Government. Although the section is of a
rovisional character, designed to cover the interim period
bove mentioned, and requires annual renewal by Parliament,
is only a "machinery provision" enabling supplementary
rrangements to be made for marketing the guaranteed produce,
nd in no way curtails the effect of the earlier and permanent
rovisions of the Act establishing guarantees of price and
arket.

Good Estate Management and Good Husbandry
—The maintenance of efficient standards of estate
anagement and of farming is dealt with by Part II of the
947 Act which came into force on 1st March, 1948. Rules
good husbandry have had statutory effect for many years
lthough prior to the 1939–45 war only in connection with the
lationship of landlord and tenant) but a code of good estate

management having statutory significance is an entirely new conception.

The duty of an owner of agricultural land is to manage the land in accordance with the rules of good estate management. This condition is satisfied when the standard of management of the holding is reasonably adequate to enable the occupier reasonably skilled in husbandry to maintain efficient production in both kind of produce and the quantity and quality thereof. This is a summary of the terms of Section 10 of the 1947 Act ; but the word " reasonably " in relation to management should be noted. The law does not insist that the owner shall manage land in the most efficient way possible—his standard must be reasonably adequate to enable efficient production to be secured and in determining the standard, regard must be had to " all relevant circumstances." This means all circumstances affecting management other than the personal circumstances of the owner himself. Accordingly, if difficulties arise in securing labour and materials for necessary work, over which the owner has no control, these are taken into account. But lack of private means is no defence for failure to discharge the obligations.

The rules of good estate management are not really rules since the Act merely contains the general statement indicated But the relevant section says that regard must be had to the extent to which the owner is providing, improving, maintaining and repairing fixed equipment. Whilst the owner can to some extent shift to the occupier, by agreement, his responsibility for maintaining and repairing fixed equipment, the owner remains fully responsible for provision and improvement, and this responsibility cannot be moved.

Fixed equipment is also a new term and is not clearly defined in the Act. Apart from any buildings or structures on the land, the term includes drainage works, farm ditches hedges and shelterbelts.

The rules of good husbandry are in greater detail than those relating to estate management. They were originally established in connection with a claim by a tenant to compensation fo disturbance. During the 1939-45 war, Defence Regulations required that the rules of good husbandry should be complied with to the satisfaction of the State and in the national interest failing which the Minister of Agriculture had power to take possession of the land. This provision is now given a permanent character by the 1947 Act.

The rules of good husbandry require that the occupier must having regard to the standard of management obtaining, the character and situation of the holding, and other " relevant circumstances " (discussed above) maintain a reasonable standard of efficient production as to type of produce and quality and quantity ; and he must also keep the holding in such a condition as will enable that standard to be maintained in the future.

The standard of farming must be " reasonable," the type of farming being taken into account. For instance, a holding may be farmed as a grass farm but should properly be converted to arable production. In such a case, however efficient the grass farming, the occupier may be breaking the rules of good husbandry. Again, the occupier must preserve the fertility of the farm. Accordingly, the production of a succession of white straw crops would seem to offend against the rules of good husbandry. But the effect of the word " reasonable " is important since if, for example, the land were shortly to go out of agricultural use, perhaps for the building of a new town, it would obviously be unreasonable to insist upon the maintenance of fertility in respect of that farm.

After the general statement concerning the principles of good husbandry, the Act specifies that the occupier must (*a*) keep permanent pasture properly mown or grazed and maintained in good fertility and condition ; (*b*) keep arable land cropped so as to maintain it clean, fertile, and in good condition : (*c*) keep the holding properly stocked, if the farming system involves the keeping of live stock ; and to maintain efficient standards of management or breeding where stock are kept or bred ; (*d*) keep stock and crops free from disease and pest infestation ; (*e*) protect and preserve crops harvested or lifted or in course of being dealt with ; and (*f*) undertake necessary works of maintenance and repair.

The responsibility for ensuring that reasonable standards of good estate management and of good husbandry are maintained rests primarily upon the County Agricultural Executive Committee. These committees have set up sub-committees dealing with estate management and husbandry, and also district committees which deal with the regular administration of Part II of the Act, subject always, of course, to the decision of the main committee in any given case. The district committees are engaged on a nation-wide survey with a view to classification of owners and farmers in respect of their standards of management and farming respectively ; and from the results of these surveys the conclusions of the C.A.E.C. will be reached upon the necessity for applying the sanctions imposed by the Act for failure to conform to the rules of management and husbandry. These sanctions are supervision, directions, and, in the last resort, dispossession.

The system of making supervision orders—for failure to conform to the rules of good husbandry—came into operation

during the 1939–45 war. This has now been extended to co
good estate management and is given permanent statutory fo
by Part II of the 1947 Act.

If the C.A.E.C. comes to the conclusion that the owner
occupier is not fulfilling his responsibility an order may be m
placing that owner or occupier under the supervision of
committee. There is no appeal against the making of such
order, but before it takes effect the person concerned is g
the chance of making representations to the C.A.E.C. ei
in writing or orally at a hearing, and in any case can be rep
sented by a lawyer or any other person whom he chooses.
practice, a supervision order is not made without care
consideration of the individual case and probably follow
an inspection of the land by the representatives of the C.A.E
(of which visit notice must be given). If the C.A.E.C. dec
to make the supervision order, copies of the order have to
served upon the person now under supervision and the ot
party, if any, interested in the land (for example, if the occup
is placed under supervision for bad husbandry, the owner
to be served with a copy of the order). But an owner-occup
may be placed under supervision in relation to his managem
or his farming or both.

The effect of a supervision order is important since anybo
properly authorised can enter on the land without notice
see how the person supervised is progressing and the Minis
acquires after a supervision order powers of direction a
dispossession.

A supervision order normally lasts for at least 12 mont
but if a person under supervision fails to comply with a direct
he may be liable for dispossession although 12 months have
passed since the order was made. The case is reviewed
least once every 12 months the order is in force when the per
under supervision again has a chance to make representatio
Besides this, however, the other party (that is the owner wh
the tenant is under supervision, or tenant where the owner is un
supervision) may also make representations on the ann
review and ask the Minister to exercise his powers of
possession. If the Minister rejects this demand the per
making it can take the matter to the Agricultural Land Tribu
if he grants it the person to be dispossessed can also refer
the Tribunal.

A supervision order has in some respects an odd eff
To a certain extent it affects the land as well as the owner
occupier, since it is not necessarily revoked by the transfer
the interest of the person under supervision. For inst
if the owner is under supervision a mere conveyance by
of the land to a purchaser or to anyone else will not e

revocation of the supervision order. Even death does not necessarily revoke the order, unless the land is left by will. Therefore any person who acquires the interest in a farm of a person under supervision, unless that acquisition is by reason of a will, continues under supervision unless and until the C.A.E.C. are persuaded to revoke the order. Revocation can take place at any time the C.A.E.C. is satisfied with the standard of management or husbandry. There is an obligation on the C.A.E.C. to register the making of a supervision order as a Local Land Charge, so that any purchaser on searching is able to learn of the existence of the order; on revocation the charge is removed.

Directions to an individual owner or farmer under Part II must be distinguished from special directions to secure production which may be given under Part V of the Act when a national emergency arises. Here the directions relating to detailed management or farming in cases where the standards prescribed by Part II are not complied with are considered.

Some directions, relating to fixed equipment, can be given without the necessity for a supervision order. Since, if the owner or occupier has failed to deal properly with one item of fixed equipment but in other respects his standards are satisfactory, it would be unfortunate if a general supervision order had to be made before directions could be given to right the isolated matter.

These directions (which can be given without a supervision order) relate only to the provision, improvement, maintenance or repair of fixed equipment. Before a direction is served the chance of making representations to the C.A.E.C. has to be given not only to the person in default, but also to the other party, that is the owner or occupier. Generally, there is no right of appeal from a direction, but where the proposal is for the provision of fixed equipment, the owner has a right of appeal to the Tribunal in two cases: (*a*) Where the cost of compliance with the direction is substantial (as defined in the Act, Section 15), and (*b*) where the land is subject to compulsory acquisition for non-agricultural purposes.

There are quite severe penalties for failure to comply with the direction when given. Apart from a maximum fine of £100 the Act gives the Minister default powers enabling him to carry out the work and to recover the reasonable cost (to be settled by arbitration).

Directions, following upon a supervision order, can be positive or negative and are not confined to fixed equipment. With respect to an owner they may direct him to entrust the management to a person appointed by him and approved by the Minister. A direction to the tenant may require him to plough up permanent pasture or to carry out other acts c cultivation. The farmer in such cases is protected in complyin with the direction in connection with any penalty under h agreement and for all legal purposes the permanent pastur ploughed up becomes arable land. The owner in this case given the chance to make representations aginst the directio and special terms may be prescribed concerning the amount land to be left under grass on quitting the holding at the en of the tenancy.

The final penalty for failure to comply with the rules of goo estate management, or the rules of good husbandry, dispossession. Dispossession is always preceded by a supe vision order and save in one instance that order must have bee in existence for at least 12 months. The exception is whe the person under supervision fails to comply with a directio

Assuming it is the owner under supervision for bad esta management and the Minister is not satisfied he is improvin then the whole or any part of the land to which the supervisio order relates can be compulsorily purchased. At any tim before compulsory purchase takes effect the owner can dispo of the land, although this does not automatically revoke t supervision order. Again, an owner wishing to resist a propos for dispossession can, if he chooses, ask the Minister to appro of a proposal to entrust the management to somebody else a to give a direction accordingly. The owner has the right make representations to the C.A.E.C. against a proposal f dispossession. If, in spite of these representations, the ord is made, the matter can be referred to the Agricultural La Tribunal. If the proposal to make the order for dispossessio is confirmed, the Minister acquires the land compulsorily a pays as compensation the amount which would be paid by a other public authority on a compulsory acquisition—t current "existing use value" of the land.

The above deals with the owner under supervision for b estate management. The dispossession of an owner-occupi or a tenant for bad husbandry must now be considered. Ea must be dealt with separately.

In the case of a tenant under supervision, the Minister, satisfied that the farm has not shown satisfactory improveme under supervision, can terminate the tenant's interest in t land as from a period not less than three months from the da of the dispossession order. That order can require the own either to farm the land himself or to let it to a tenant approv by the Minister. In the case of an owner-occupier und supervision for bad husbandry, the dispossession order m direct the owner-occupier to give up occupation at a date n

lier than three months from the time of making the order
d to let the farm to a tenant approved by the Minister.

In the case of dispossession for bad husbandry, therefore,
owner-occupier has to let the farm to a tenant approved
the Minister, or where the dispossession is of a tenant the
ner has to farm the land himself or again let it to an approved
ant. The Act also states that if no arrangements satis-
tory to the Minister are made under this provision the
inister (that is the C.A.E.C.) can take possession of the land
the purpose of farming it when either the land will be
med direct by the C.A.E.C. or let by them to a private
rson similarly placed to a tenant having possession on the
ms of a contract with the C.A.E.C. The Act further contem-
ates that in the last-mentioned case the arrangement
rminates if and when the owner enters into a tenancy agree-
ent direct with the private person who contracted with the
A.E.C. for the farming of the land.

AGRICULTURAL HOLDINGS.—The law relating to agri-
ltural holdings is now embodied in the Agricultural Holdings
t, 1948, which came into force on 31st July, 1948. This
t consolidated, without amendment, the Agricultural Holdings
t, 1923, and Part III of the Agriculture Act, 1947. The Act
ovides a new definition of "agricultural holding," that is
e aggregate of the agricultural land comprised in a contract
tenancy. For all practical purposes the 364-day tenancy
abolished. Unless the prior consent of the C.A.E.C. is
tained in a given case, all 364-day tenancies are to be treated
yearly tenancies except in the case of land let or licensed for
rt of a year for mowing or grazing.

Provision is made to ensure that either party can insist that
e tenancy agreement involved is in writing, and that written
reements cover all the important points such as liability for
tgoings, covenants for replacement of assets damaged or
troyed by fire, and for insurance. Therefore, where an
reement is oral or if in writing does not cover all the cardinal
ints, either party may ask the arbitrator to commit to writing
e actual agreement of the parties.

A new power is given to the Minister by the Act to prescribe
statutory clause as to maintenance, repair and insurance of
ed equipment. The Minister has in fact exercised this power,
d has prescribed the clause by Regulations. This divides
sponsibility for maintenance and repair by giving certain
ks to the landlord and others to the tenant. The landlord's
ks are mainly concerned with exterior works and works of
structural character, whereas the tenant has to undertake

interior work and other matters closely connected with actual farming operations, such as hedging and ditching.

The clause will not, however, apply in so far as specific provisions on the same subject are included in existing written agreements. But if an agreement, old or new, does make specific provision substantially departing from the statutory clause, either side may ask the arbitrator to consider variation of the terms.

Either party to a tenancy agreement can under the Act, on giving notice to the other party, demand arbitration on rent. This does not apply to a lease for a period of years. Once fixed by agreement, or by the arbitrator, the rent stands for at least three years before an arbitrator can be asked to consider the matter again, unless an increase in rent is proposed as a result of improvements carried out under statutory direction or provision.

The terms of an agreement relating to permanent pasture may also be varied by the Minister in the interests of efficient farming. The Act contains complicated provisions to this end. These enable a person given a direction to plough up permanent pasture to be exempted from any liability in respect of that action and conditions may be made concerning the amount of pasture to be left on quitting (not to exceed the original amount specified in the agreement). Conditions may also be made on the amount of compensation due to the tenant for pasture so left.

Under the 1923 Act the tenant had certain rights with respect to disposal of produce and freedom of cropping of arable land. These rights remain substantially unaltered in the new Act as also the tenant's right to retain and remove tenant's fixtures and buildings, but notice by the tenant of the proposed removal of a fixture or building must be given at least one month before the termination of the tenancy; the right to remove is not exercisable after two months have elapsed from the termination of the tenancy.

The law with respect to distress for rent was not altered by the 1947 Act and accordingly remains in force as contained in the Agricultural Holdings Act, 1923, subject to purely drafting amendments which were made in the 1948 Act.

Notice to Quit—In connection with notice to quit, the law has been substantially altered. In the first place the old rule that at least 12 months' notice to quit an agricultural holding must be given, to expire at the end of a tenancy year, is preserved; and this general rule now applies equally to notice to quit part of a holding (where such a notice can be validly given). But the 1948 Act includes certain provisions, originally comprised in the 1947 Act, the object of which is to give the good tenant security of tenure by placing restrictions on the validity of notices to quit served by a landlord. When such a notice to quit is given the tenant can, within a month, serve a counter notice demanding the consent of the Minister. If he does not serve this counter notice consent is not required to make the notice to quit valid. Nor can the Minister's consent be demanded in cases in which the landlord would not be liable for compensation for disturbance or where the land is required for some approved non-agricultural purpose.

The over-riding principle of this consent provision is that the Minister must refuse consent unless he is satisfied on at least one of five points. Even if so satisfied he can still withhold consent or impose conditions upon granting it. Briefly the five points are :—

(*a*) that notice is given for a purpose desirable in the interests of efficient farming ;

(*b*) that it is desirable in the interests of research, education, experiment or of the provision of smallholdings ;

(*c*) that the tenancy began after 5th August, 1947, and that possession is required for a purpose specified in the agreement, and that greater hardship would be caused by refusal than by consent ;

(*d*) that in the case where the tenancy was created before 6th August, 1947, and there has been no change in landlord between that date and service of notice to quit or application for consent, greater hardship would result from refusal than from consent ; and

(*e*) that there is to be an approved change to non-agricultural use.

In all cases of proposal to grant or refuse consent to the notice to quit the parties concerned can make representations to the C.A.E.C. and may appeal from the C.A.E.C.'s conclusion to the Tribunal.

Provision is also made by the Act for the case in which the holding is agreed to be sold during the currency of a notice to quit, in effect giving the tenant an option to treat the notice as good or bad.

Compensation for Disturbance—The new law makes no serious change in connection with compensation for disturbance—which is still based on loss or expense sustained by the tenant being not more than one year's rent nor more than two. As before, the right to this compensation is excluded by bad husbandry, failure to pay rent or to remedy some other breach of covenant, bankruptcy, or death of the tenant within three months prior to the notice to quit.

Of bad husbandry it should be noted that the certificate m
be obtained before the notice to quit is served. Applicati
for the certificate of bad husbandry has now to be made to
Minister and no certificate is issued while a supervision or
is in force. Instead of granting such a certificate the Minis
can make a supervision order. An appeal may be made
the Tribunal against any decision to grant or refuse a certific
but not against a decision to make a supervision orde
accordingly an arbitrator is no longer involved in this matt

Compensation for Improvements—It should first be clea
understood that the law with respect to compensation
improvements begun before 1st March, 1948, remains unalter
Accordingly, the position of outgoing tenants in connecti
with compensation for improvements will in respect of
those begun before that date be governed by the old la
that is the Agricultural Holdings Act, 1923. New provisio
are, however, made in respect of improvements begun on
after 1st March, 1948, and in respect of tenant right matters

New improvements are now divided into "long term"
out in the Third Schedule to the 1948 Act and "medi
term" set out in Part I of the Fourth Schedule. The lo
term improvements are themselves divided into two grou
that is, (*a*) those of such substance as might alter the charac
of the holding; as to these the landlord's consent must
obtained if compensation is to be claimed; and (*b*) th
which would not have the same effect, in respect of whi
therefore, either the consent of the landlord or of the Minis
may be given. An example of an improvement which m
have the landlord's consent if compensation is to be claim
is the making of works of irrigation; the principal exam
of improvements in respect of which either the consent of
landlord or of the Minister must be obtained to preserve t
to compensation is the erection, alteration or enlargement
buildings.

Where the landlord in the latter case refuses consent
tenant can approach the Minister (C.A.E.C.). After hear
both parties the committee may give consent, in which c
the landlord is given the chance of doing the improvem
himself.

The medium-term improvements set out in Part I of
Fourth Schedule require no consent, but notice to the land
must be given in respect of any plans to carry out mole drai
works (which come within Part I of the Fourth Sched
The making of watercress beds is added as a long-term impro
ment requiring the landlord's consent whilst the provision
electric light or power, means of sewage disposal, and

wing of herbage crops for commercial seed production w appear in the group requiring the consent of the landlord the Minister.

and drainage generally (which previously required notice y) now requires the consent of the landlord or Minister, ice only is needed for mole drainage, the latter being the y improvement appearing in Part I of the Fourth Schedule which notice is necessary. The old items appearing in Schedule of improvements in the 1923 Act are reproduced h alterations, some of which are important. For example, ded poultry are brought in with horses, cattle, sheep and s, in relation to consumption of feedingstuffs not produced the holding.

he list of improvements may be varied by the Minister by ulation ; but this can only be done after consultation with lies representing landlords and tenants, and any Order king a variation requires affirmative resolution of both uses of Parliament.

t should also be observed that in respect of improvements un on or after 1st March, 1948, compensation may be imed even though such improvements were carried out in last year of the tenancy.

Mention should be made of the measure of compensation. ile as before, in regard to medium-term improvements and ant right, the measure is based upon the value to an inning tenant, the new basis for long-term improvements is effect a capitalisation of the increased rental value due to improvement. With long-term improvements the parties come to an agreement, varying this basis, but no concting out is permitted with respect to the measure of comsation for medium-term improvements.

enant Right—In this field also an important change made. The 1948 Act lays down that, apart from existing ancies, the out-going tenant can no longer base his claim on the custom of the country but will instead claim comsation on the basis of the value to an incoming tenant by ue of the Act. The method of calculating valuations has n reported upon by an expert committee, including represenves of all interests in the industry, and this forms the basis settlement of tenant right claims. It is, however, always n to the parties by written tenancy agreement to deal with ant right in whatever manner they wish, for example, by stituting a different measure of compensation from that down in the Act, and the Act also provides that with ancies existing on 1st March, 1948, the tenant can elect d be made to elect before he leaves) whether he wishes to go out on the old basis or on the new one which the A provides.

Statutory provision is also made for compensation for hig farming and conversely for dilapidations. Finally, the syste of settlement of claims by arbitration is preserved and extende by the 1948 Act and all claims between landlord and tenan arising on or out of the termination of the tenancy are to b referred to arbitration under the 1923 Act procedure.

Smallholdings—Part IV of the Agriculture Act, 1947, dea exclusively with smallholdings, and provides the statutor framework for a new Government policy for the provision o smallholdings. This part of the Act extends only to Englan and Wales and came into operation on 1st October, 1949.

The principal feature of the new policy is that only a perso possessing sufficient agricultural experience to make it likely th he is, or is likely to become, qualified to be a farmer on his ow account will be considered as an applicant for a smallholdin the main objective being to provide a ladder of opportuni for such persons with limited capital to acquire independen in agriculture. In short the present policy may be contrast with that obtaining in the past in that formerly the prin considerations were of a social character designed to assist th settlement of ex-servicemen and unemployed from indust on the land, whereas now the objective is the provision of career for agricultural workers and others concerned wi agriculture in a like economic position.

The duty to provide smallholdings is imposed by the A upon every county council (except the London County Counc wherever there is a demand therefor in the county. The councils, known for this purpose as smallholdings authoriti are given the power to acquire land to provide smallholding either by agreement or compulsorily, subject to the Minister approval. The smallholdings authority provides and maintai fixed equipment on the holdings, but in the absence of a general directions given by the Minister an authority can on proceed to establish and equip smallholdings in accordance wi a scheme submitted to and approved by the Minister.

As to finance, the Minister may contribute up to 75 per cen of any estimated loss anticipated by a smallholdings authori in connection with a proposed scheme, and detailed provisi is made for keeping accounts for this purpose. Smallholdin authorities have no power to sell holdings to their tenan thereby preventing any decrease in the amount of land availa for letting to a succession of smallholding tenants. T tenants themselves may, under the Act, be provided wi working capital by loans of an amount up to 75 per cent. the estimated aggregate working capital required.

The powers of county councils in connection with smallholdings are exercised through smallholdings committees. The majority of members of these committees consist of members of the council but other persons may be appointed to serve; in particular arrangements are made for an officer of the Minister, normally the Land Commissioner, to be present at meetings of the smallholdings committee.

A smallholding is defined by the Act as a holding of more than one but not more than 50 acres, or between 50 and 75 acres, provided in the latter case that the full fair rent does not exceed £150. In every case the holding must be let at a "full fair rent," that is a rent such as a tenant might reasonably be expected to pay for the holding as such and on the terms on which it is in fact let.

Quite apart from the 1947 Act the Minister has set up a Smallholdings Advisory Council. This council published its first report on 11th March, 1949, giving a series of recommendations on administration of smallholdings and summarising the history of the subject and the effect of the new law.

Administration—Under Part V of the 1947 Act the necessary provision is made for administration of the new law established by the earlier parts of the Act. Three new bodies are set up on a statutory basis.

The first is the Agricultural Land Commission having the function to manage and farm land vested in the Minister and to advise the Minister on problems of management. The Commission is a small body of persons directly appointed by the Minister. It has no power to buy or sell land but may let holdings (which are in State ownership) on yearly tenancies. A separate sub-commission for Wales and Monmouthshire was also established under the Act. The Commissions are mainly concerned with matters of general policy and other specific functions given to them under the Act, whereas all the "field work" is done through the County Agricultural Executive Committees and the Agricultural Land Service.

These C.A.E. Committees set up by this part of the Act consist of 12 members, seven of whom are "nominated members" appointed by the Minister from panels submitted by the organisations representing farmers, owners and workers. The other five members are directly appointed by the Minister and include one member of the appropriate county council and persons having special knowledge or experience.

The C.A.E.C. act through sub-committees and district committees. The district committees have powers of report and recommendation only, but executive power may be delegated to a sub-committee. In fact, the C.A.E.C.'s with their

sub-committees and district committees administer most
the provisions of Part II of the Act relating to good est
management and good husbandry.

The third new body set up by the Act for purposes of admin
tration is the Agricultural Land Tribunal concerned
connection with a number of matters to hear appeals aga
decisions which affect the owner or occupier of agricultu
land. The decision of the Tribunal in any particular case
final. The chairman is a lawyer and the other two memb
of the Tribunal are selected from panels nominated by t
organizations representing owners and farmers. Assess
drawn from a professional panel (of surveyors, valuers, et
may be appointed for a given case. The procedure of t
Tribunal is worked out in detail in special Regulations ma
under the Act.

Acquisition of Land—Wide powers are given to t
Minister to acquire or hire compulsorily or by agreeme
agricultural land for various purposes. These include t
power to acquire land where the Minister considers that t
and efficient use is prevented because work is not being done
equipment is not being provided or maintained. In t
special case the matter is referred to the Agricultural La
Commission for investigation and report and opportunity
given to the parties concerned to state their case before
decision is reached.

The Act also deals with cases where the Minister is in posse
ion of land under war-time powers in respect of which he m
exercise powers of compulsory acquisition instead of return
it to the person from whom it was requisitioned. If t
Minister decides to acquire, any person interested in the la
can appeal to the Tribunal.

Reference should also be made to a new provision enabl
the Agricultural Land Commission to carry out a limi
number of experimental schemes for re-adjustment of fa
boundaries. The first experiment of this kind being undertak
by the Commission in respect of land at Yetminster, Dors
Another power to acquire land compulsorily is conferred
the Act for the purpose of preventing the breaking up of fa
units into uneconomic parts.

Wherever compulsory purchase takes place as a result of
exercise of powers under the Act, compensation is paid at
full "existing use value," that is, the current market value
agricultural purposes. There is also power for land to be h
by the State, but where this is done the limit of the hiring i
term of 35 years.

Special Directions—The Act provides that an order may e made by Parliament giving the Minister power to erve directions on any or all farmers for the purpose of ecuring food production during a critical period, such as the utbreak of war or a national economic crisis of the first agnitude. The type of direction varies according to the rcumstances; it may relate to the growing of a specified rop, or require the maintenance of a specified acreage under llage, and so on. This power can only be exercised under afeguards and requires an order to be confirmed by resolution f both Houses of Parliament. By the summer of 1950 no order ad been made empowering the issue of cropping orders, but irections may be given under an order which came into force n 31st July, 1948, for maintenance of the acreage under tillage rops.

The concluding provisions of the Act deal with general dministrative matters. Power is given for the continuation of xchequer contributions towards field drainage works, improveents of ditches, farm water supply schemes, and the cost of ming; and some improvements are made in the lime scheme.

New provisions relating to control of pests and weeds also ppear, and these are on a somewhat similar basis to the egulations operating during the war but with additional afeguards.

Finally, a statutory basis is given to the scheme for provision f agricultural goods and services by County Agricultural xecutive Committees.

This concludes the necessarily brief description of the griculture Act, 1947, and the Agricultural Holdings Act, 1948. ogether they represent the most comprehensive statutory pproach yet made to the agricultural industry. But it is orth repeating that these Acts are a legal vehicle for, and not substitute for, a long-term agricultural policy.

TOWN AND COUNTRY PLANNING ACT, 1947

This Act made a fundamental change in the rights attaching to ownership and possession of land ; its effects may best be considered under three main heads, i.e. (*a*) Planning Control (*b*) Development Charge ; and (*c*) Compensation.

Late in 1952 proposals were announced by the Governmen for drastic amendment of the 1947 Act in respect to (*b*) and (*c*) above.

(*a*) **Planning Control**—The first object and effect of the Ac was to control the manner in which every piece of land in the country is used, and the Government proposals announced in November, 1952, intimated there was no intention of altering this objective of the Act. Planning authorities are constituted by the Act in order to exercise control ; these authorities are every county council and county borough council, and authorities may combine to constitute joint planning authorities

The Act provided that by the 1st July, 1951, every planning authority should prepare a development plan for submission to the Minister (now the Minister of Housing and Local Govern ment) showing in outline the use to be made of all land in the area covered by the authority. Areas were to be earmarked for agriculture, industrial development, housing, green belts and so on. In practice very few plans were submitted by the 1st July, 1951, and several had still to be prepared in December 1952.

The submission of the plan to the Minister had to be advertised in the local press indicating where the plan could be inspected and how objections could be submitted. An person could record an objection to the plan, which must be considered by the Minister. Ultimately the Minister con firmed the plan with or without alteration, but before doin so an oral hearing had to be given to all who had objected— usually at a public local inquiry.

Under the Act land cannot be "developed" without the consent of the planning authority for the area. "Develop is a technical term and broadly speaking covers the buildin upon or mining of land or the change of the use to which land or buildings are being put. A man "develops" his land if he builds a house on it, digs gravel, or converts a house into an hotel.

If the planning authority grant permission for development they may attach conditions. They may for example require the design of any building to conform to certain standards. But if the authority refuse permission to develop, or grant permission subject to conditions which the developer is not prepared to accept, he may appeal to the Minister. This appeal has to be lodged within one month of the receipt of the authority's notification that planning permission has been granted or refused. There is no right of appeal from the Minister's decision. If the applicant can show, however, that the land is incapable of "reasonably beneficial use" if he uses it only in the way which the planning authority is prepared to allow, he may demand that the local authority shall buy the land. The decision on this question rests again with the Minister. In some cases a developer who is refused permission can claim payment of compensation, that is if the development which he wanted to carry out was of the kind specified in Part II of the Third Schedule to the Act.

The Government's proposals for amendment of the Act contemplate that in the parliamentary session 1953-54 a new Bill will be introduced which will make provision for payment of compensation where planning permission is refused, in cases not covered by the 1947 Act; but the details had not, in December, 1952, been worked out. Any claim for compensation payable under the 1947 Act may be made as soon as planning permission is finally refused and the amount is fixed by arbitration, (if necessary) at the loss in value of the land due to refusal of planning permission.

A development plan may indicate areas which the planning authority consider will eventually have to be acquired by the State or a public authority. If and when the time comes for such acquisition the usual procedure (if the acquisition is compulsory) will be followed. In practice, however, it is necessary for the objector to make sure that his objection to compulsory acquisition is made at the time when the development plan is prepared and published since a later objection may be disregarded if, in substance, it amounts to an objection to the plan already approved.

The Act empowers the Minister to permit generally (and without any special application) certain specified types of development by Order. Such an Order called the Town and Country Planning (General Development Order), 1950, was made on the 8th May, 1950, and came into force on the 22nd May, 1950. This is of great importance to agriculture. Under this Order the owner or occupier can carry out on agricultura land, having an area of more than one acre and comprised in an agricultural unit, any building or engineering operation requisite for the use of the land for the purposes of agriculture other than the placing on land of structures not designed fo those purposes, or the provision and alteration of dwellings Thus farm buildings necessary for agricultural purposes car normally be erected without applying for planning permission unless they are sited near an aerodrome or a public road Planning permission must be obtained, however, before a dwelling house, be it farmhouse or worker's cottage, can b built.

Special considerations apply to agricultural holdings within certain National Park areas, i.e., Snowdonia, the Lakes and the Peak District. In these cases the general permission given by the Order mentioned above will not apply and before erecting altering or extending an immoveable structure, 14 days written notice must be given to the local planning authority together with a short description of the proposed building, the materials to be used and a site plan. If the local plannin authority do nothing within 14 days, the developer may go ahead ; but they may in that period require prior approva to the design and external appearance of the building before any development is begun.

It should be carefully noted that exemption from plannin permission under the Act—or indeed the granting of planning permission—does not give exemption from building by-law or other requirements not connected with planning for whic the local authority should be consulted.

Application for planning permission under the Act is mad on a form obtained from the district council. The applicatio with accompanying plans (as specified on the form) is submitted to the district council, which passes them to the plannin authority. A decision must generally be reached and th applicant notified within two months. If a decision is no received within this time, the application is deemed to b refused when an appeal to the Minister should be made withou waiting for any further communication from the plannin authority.

(*b*) **Development Charge.** This was an entirely new conceptio introduced by the 1947 Act. In fact, however, farmers wer never very much concerned with the matter except in respe to dwelling houses.

The idea of the 1947 Act was that every piece of land has tw distinct values (i) a value as a site for development (th "unrestricted" value), and (ii) a value on the basis that no development would ever be permitted on the land (the "restricted" value); the difference between these two values is called the development value.

The intention of the Act was to forfeit to the State the development value of all land in England and Wales. It also forfeited from the owner the right to develop his land. He could, however, buy that right back from the State at a price known as the development charge; and as from the time when the Act came into force up to the 18th November, 1952, no man had any right to develop his land to any material extent unless he first paid or secured this development charge to the State. Development charge was assessed and collected by a body set up under the Act called the Central Land Board, with headquarters in London and 14 regional offices throughout England and Wales. The arrangements, however, for assessment and collection of development charge are now largely of historical interest only since the Government proposals for amendment of the 1947 Act published in November, 1952, announced the decision, to be confirmed by measures to be brought before Parliament, to abolish the liability for development charge in respect of all development begun on or after the 18th November, 1952. If development began before the 18th November the whole of the development remains liable to the charge, but where the charge was paid in advance and development did not commence until on or after the 18th November, the amount of the charge will be repaid. This last mentioned case is the only one in which development charge will be repaid, since the Government's proposals make it clear that there can be no question of repaying development charge as such, though some people who have paid the charge in the past may be entitled to claim compensation.

(*c*) **Claims for compensation for loss of development value**—When the 1947 Act was passed the Government of the day took the view, which was embodied in the Act, that the landowner who lost development value had no right to compensation for his loss; but a sum of £300 million was set aside out of which compensation could be paid to such owners. Any owner who claimed that he had sustained such a loss had to submit his claim by the 30th June, 1949. When the claims were lodged, a scheme was to be drawn up by the Treasury for payment or division of the fund amongst claimants; and the Act provided that payments of compensation were to be made in negotiable Government Stock in July, 1953.

The Government's proposals of November, 1952, contemplate a very drastic change in these arrangements, but it is a mistake to think that the new proposals mean anything like a return to the conditions with respect to sale of land for development (apart from planning control) which existed before the 1947 Act was passed. The essential thread of principle running through the proposals seems to be that the Government will only recognise for compensation purposes, development value which had accrued in respect of any given area of land, by the 1st July, 1948, and which is the subject of a claim already admitted against the £300 million fund. In other words, development value, as it were, " crystallized " on that date and any further accretions (or reduction) in development value of a particular piece of land since that time is irrelevant to any claim for compensation on acquisition, or for refusal of permission to develop.

The proposals contemplate the passing of a Bill before July, 1953, which will cancel the £300 million fund. There will, therefore, be no general distribution of compensation as was laid down by the 1947 Act. Incidentally the total admitted claims on that fund are likely to be of the order of £350 million and it has been estimated that after meeting preferential claims amounting to about £100 million (to be paid in full) the remaining claims would probably have been met by a payment of about 16s. in the pound.

Now, however, compensation will be paid in future for loss of development value in individual instances as and when they occur, as well as in respect of cases which have arisen since the 1947 Act came into force. The cases in which compensation may be payable will be either those in which land is acquired, or those in which planning permission is refused or restrictions imposed.

Up to now where land has been compulsorily acquired since the 1947 Act became law, the compensation payable was based upon the " existing use value " of the land without any addition for loss of development value. But once the second instalment of legislation contemplated by the Government's proposals is passed in the 1953/54 session there will in addition be paid compensation for the loss of development value to the extent that there is an admitted claim on the £300 millio fund already in existence. Moreover, in cases of acquisitio between the 18th November, 1952, and the passing of the amending Bill above mentioned, payment of the additiona compensation will be made retrospectively. Again if a landowner is refused permission to develop on planning grounds he may be entitled to claim compensation in respect of that refusal, again to the extent of any admitted claim for loss of development value. Similarly such compensation will be payable in respect of certain planning restrictions on development but the details of these cases had not, in December, 1952, been fully worked out.

Apart from compulsory acquisition sales of land in future will take place at market value. This will, of course, be affected by planning permission, but subject thereto the price of land should include its full development value. The Government's proposals, however, sound a note of warning here in that they recall that local authorities have powers to buy land compulsorily in order to make it available to private developers, if for instance a landowner were to hold out for an unreasonable price and the building or development was something which the public badly needed and for which planning permission had been given.

To sum up, the theory underlying the Act as modified by the new proposals is that from November, 1952, the landowner will have the advantage of a " free market " on sale of his land in the sense that he can ask whatever price he thinks appropriate, subject to the effect thereon of planning control and to the note of warning sounded by the Government's proposals about action by public authorities. But so far as the Government is concerned they will only recognise the title of the landowner to development value so far as this had accrued on the 1st July, 1948, and is the subject of an admitted claim for compensation.

AGRICULTURAL MARKETING ACTS

The first Agricultural Marketing Act became law at the end of July, 1931. It had the distinction of being annotated in a Report which was published as an Orange Book in the Ministry of Agriculture's Economic Series. The Report contended that large scale organisations were daily becoming more necessary, alike for those commodities mainly affected by internal competition and for those particularly subject also to the competition of imports. " The task of forming such organisations on voluntary lines would be formidable," it proceeded. " The task of holding together such organisations, even if formed, would be still more formidable so long as a minority of producers could stand by and leave to others the obligations and responsibilities which should, in fairness, be borne by all. Unity of plan and unity of execution connote discipline of the whole and not merely of a part."

That was the situation which the 1931 Act was designed to meet. Of schemes under the Act the Report declared that "democratic control in the administration of every scheme is assured by the fact that the board, i.e., the administrative body entrusted with the administration of the scheme, is composed of the elected representatives of registered producers."

The Hops Marketing Board was the first to come into existence, followed by Boards to handle milk, bacon pigs and potatoes. Provision for the control of imports was embodied in the Agricultural Marketing Act of 1933.

On the outbreak of the war in 1939 the Marketing Boards were put into cold storage on the institution of food control. (The Milk Marketing Boards continued to function in accordance with Ministerial instructions, but the English Board functioned on its own initiative in such matters as administering milk records and the setting up of Artificial Insemination Centres.) The explicit assurance was given that their powers would be restored after the cessation of hostilities. It remains to be seen whether that assurance will be implemented and whether "democratic control" will be preserved. So far as the launching of new schemes under the Act is concerned, the situation is further complicated by the Treaty commitments entered into by the Government since 1945, the problem of international trade "liberalisation" and the limitations of the 1947 Agriculture Act "guarantees" to farmers in respect to prices and markets.

The main features of the Marketing Acts are summarised below :

Agricultural Marketing Act, 1931—

The Act enables a scheme regulating the marketing of an agricultural or horticultural product by its producers to be submitted to the Minister of Agriculture for his approval. ("Product" includes articles of food or drink wholly or partly manufactured or derived from it, as well as fleeces and the skins of animals.) The scheme may apply to the whole or any part of Great Britain.

MARKETING SCHEMES—A scheme has to be submitted by persons substantially representative of the producers in the area which it covers. Objections must be submitted to the Minister in writing and must state the specific modifications required. Both Houses of Parliament have to approve the scheme in draft and the Minister then makes an Order approving it and prescribing the date on which it is to come into force. All producers who apply must be registered under the scheme. After the Minister has approved the scheme, the registered producers decide on a poll whether it is to continue. If less than half the total number of producers vote, the Minister will revoke the scheme. If the vote is adverse, i.e., if the vote in favour of the scheme is less than two-thirds of those voting in terms of both numbers and output, the scheme will cease to have effect from the date of the declaration of the poll.

A scheme must provide for the setting up of a Board to administer it and for the election of members. During the first 12 months a Board will include two nominees of the Minister. (But *see* 1949 Act *infra.*)

Provision is made for the amendment of schemes and also for their revocation.

There are various provisions which *must* be embodied in schemes. These include:

Prohibition of sales of the regulated product by producers who are not registered or exempted.

Exemption by the Board of producers and sales of specified classes or descriptions of the regulated product.

Imposition of penalties by the Board for contraventions of the scheme by registered producers. (*See* 1949 Act *infra.*)

Provision for establishment of any market or slaughterhouse if desired by the Board.

Assessment and levying of contributions from registered producers to a fund from which payments will be made to secure the equitable operation of the scheme as between the producers. (But *see* 1933 Act *infra.*)

There are other provisions which *may* be embodied in schemes. These include:

Power to buy, sell, grade, pack, store, adapt for sale, insure, advertise, and transport the regulated product.

Power to require registered producers to sell the regulated product only through the agency of the Board.

Power to determine the kind, variety or grade of the regulated product which may be sold; fix maximum and minimum prices, and to whom, and on what terms, the product may be sold.

Power to regulate the grading, marking, packing, etc., of the regulated product.

Inspection of the land and premises of producers.

Encouragement of agricultural co-operation, research ar education.

POWERS OF THE MINISTER—Amongst the duties and powe conferred by the Act upon the Minister of Agriculture are

He is required to publish notice of the submission of scheme where copies can be obtained and the time within whi objections and representations may be made.

He must consider objections and representations and hold public enquiry unless the objection has been withdrawn or considered frivolous or has been met by modifications of th scheme.

He must consider the report on the enquiry and noti nominees of the promoters of the scheme of any propose modifications. The Minister will take no further action regard to the scheme unless the proposed modifications ar accepted by the promoters' nominees. He must satisfy himse that a scheme will promote the more efficient production ar marketing of the regulated product.

In connection with a poll of producers the Minister ma cause a list of the names and addresses of producers affecte to be compiled and supply the list to the Board.

He may make a loan for the expenses of the initial poll.

He is required, where a scheme comes into force, to appoi a Consumers' Committee and a Committee of Investigatio The former will represent the interests of consumers of regulate products and the latter will consider reports of the Consumer Committee and complaints outside its scope.

He may also appoint Agricultural Marketing Reorganisatio Commissions to prepare model schemes for the considerati of producers. These Commissions may also be called upo to investigate and make recommendations upon matte affecting the operation of schemes.

TYPES OF SCHEMES—The Act provides for three main kin of organisation, viz. (i) a trading Board which buys and se the regulated product or acts as sole agent for its sale, and ma engage in manufacturing commodities from the regulate product ; (ii) a regulating Board with the sole duty of givi instructions as to the methods and operations to be adopted marketing the regulated product, and (iii) a Board exercisi both trading and regulatory functions.

Provision is made for "Substitutional Schemes," i. schemes revoking and replacing one or more existing schem and providing for the registration of the same producers were affected by the previous scheme or schemes.

AGRICULTURAL MARKETING FUNDS—The Act requir Agricultural Marketing Funds to be established for Engla nd Scotland from which loans may be made to Boards. The nglish Fund is controlled by the Minister of Agriculture. he sums to be paid into it must not exceed £500,000 in the ggregate.

The task of making recommendations in regard to the aking and renewal of loans from the Funds is entrusted to gricultural Marketing Facilities Committees.

gricultural Marketing Act, 1933

Regulation of Imports—This Act empowers the Board of rade, after consultation with the Minister of Agriculture and he Secretaries of State concerned with agriculture in Scotland nd Northern Ireland, to make orders regulating the im- ortation of agricultural products into the U.K. The making f orders is dependent upon the Board being satisfied that all racticable and necessary steps have been, or are being, taken o reorganise under marketing schemes the branches of U.K. griculture concerned and that their reorganisation and develop- ent cannot be achieved or maintained without such orders. mports may be regulated by determining for any specified eriod the quantity of the product and the descriptions of the roduct which may be imported.

The Board of Trade must have regard to the interests of onsumers of the product concerned and to the likely effect of n order on commercial relations between the U.K. and other ountries. The Board must also be satisfied that an order ould not conflict with any treaty, convention or agreement ith any other country. Where the importation of an agri- ultural product is regulated by an order and the Board of rade certify that arrangements have been made for con- rolling such importation, the above-mentioned Agricultural inisters, if they are satisfied that it will promote the efficient eorganisation or organised development of any branch of .K. agriculture or necessary to secure its economic stability, ay make an order regulating sales of the product by persons roducing it in the U.K. or by Agricultural Marketing Boards y determining for any specific period the descriptions and uantity of the product which may be sold. Before an order s made, the Board of Trade, the Market Supply Committee nd any Marketing Boards concerned must be consulted.

The above-mentioned Agricultural Ministers were required o set up a Market Supply Committee for the U.K., but this rovision was repealed by the 1949 Act.

Development Schemes—The Second Part of the Act dealt ith Development Schemes, but these provisions were repealed y the 1949 Act.

AMENDMENTS OF 1931 ACT—A Marketing Board is give power to determine from time to time the quantity of th regulated product or any description of it which a registere producer may sell.

This power can only be exercised if the Board requests th Minister to make an Order effecting the necessary modification of the marketing scheme.

Marketing Boards are enabled to pool the proceeds of sale of a regulated product.

The Act amended the provisions relating to the compositio of Boards, but *see* the 1949 Act *infra* for further provision o the subject.

Boards approved after 18th July, 1933, are required t appoint an Executive Committee of not more than seve members, to whom all the functions of the Board must b delegated with the exception of any specified in the scheme One of the seven members must be a member of the Boar nominated by the Minister.

The provision relating to payment of compensation to secur the equitable operation of a scheme as between all registere producers ceases to have effect, but compensation may b paid in such class of cases as may be specified in the scheme.

After 18th July, 1933, contracts for the sale of eggs in she laid by domestic fowls or ducks are void unless the eggs ar sold by weight or under a grade designation: this does nc apply to any contract (*a*) for the sale of less than 25 eggs c (*b*) relating to eggs produced outside Great Britain or to b delivered outside Great Britain.

Agricultural Marketing (No. 2) Act, 1933.

Power to pay compensation is extended to enable a schem to provide for empowering the Board in a specified class c cases to pay compensation to registered producers in respe of any loss occasioned, in the Board's opinion, by the operatio of any scheme, whether administered by that Board or no

The powers of Marketing Boards to purchase and deal wit products are extended so that a scheme may provide fc empowering a Board (*a*) to buy from another Board admini tering any corresponding scheme any product the marketing which is regulated thereunder; (*b*) to produce from an purchased product any commodity which the Board ar authorised to produce; (*c*) to sell, grade, pack, store, adar for sale, insure, advertise and transport any purchased produ and any commodity produced therefrom, and (*d*) to exerci as agents for the Board administering a corresponding schem any power of that Board to deal in any manner mentioned i (*c*) with any product controlled by the corresponding schem

gricultural Marketing Act, 1949

Composition of Boards—Schemes must be framed so as to cure that the total number of members of a Board shall be ot less than eight nor (unless for special reasons the Minister inks fit to allow a greater number) more than 24.

Of these members, not less than two and not more than ne-fifth must be persons appointed by the Minister for their perience and capacity in commerce, finance, administration, ublic affairs or the organisation of workers or as being specially onversant with the interests of consumers of the regulated roduct.

Imposition of Penalties, etc.—Schemes must be framed so s to require the setting-up by the Board of a "disciplinary ommittee" of not less than four nor more than six members f the Board under an independent chairman, who must be a arrister or advocate or solicitor of not less than seven years' anding and approved by the Minister.

Powers of Boards—The Act extends the powers which *may* e included in a marketing scheme by empowering a Board) to manufacture or acquire and to sell or let for hire to gistered producers and other persons, anything required for e production, grading, packing, storing, adaptation for sale, ansport or sale of the registered product and (*b*) to render registered producers and other persons, on payment or herwise, any service calculated to promote the more efficient roduction, grading, packing, storing, adaptation for sale, ansportation or sale of the regulated product. If these powers e included in a scheme, the provision must be so framed as secure that the things sold or let for hire and the services ndered are likely to be utilized, wholly or mainly, by or in onnection with the regulated product produced by regis- red producers.

FARM INSURANCE

Insurance, at least against certain risks, should be regarded as essential by well-equipped and progressive farmers. Without insurance the fruits of a lifetime's work can be lost in a few hours.

The idea of insurance is not new. In earliest days tribes made collections of tools, weapons, etc., to form stores from which to help any members who lost their possessions by, say, fire. To-day, insurance is, as then, simply a means of ensuring that the misfortunes of the few fall lightly on the shoulders of the many ; the man who has a fire loses no more than everybody else, i.e., the money each has paid in premiums. In essentials then, insurance is a mutual arrangement made by any convenient number of people.

Kinds of Companies—There are three kinds of insurance companies (i) tariff, (ii) non-tariff or independent, and (iii) mutual ; the largest of those operating to-day include some of each kind.

Tariff offices work to the same tariffs or rates for most kinds of insurance, being members or an association which binds them to charge fixed minimum premiums for certain risks and include only certain benefits in their policies. These offices believe the prevention of unrestricted (and perhaps progressively uneconomic) competition is eventually a benefit to the insuring public for whom financial stability is paramount. **Non-tariff offices** are not bound in this manner but work independently and tend to charge slightly lower premiums besides being able to widen the scope of their policies as they wish.

Mutual companies are necessarily independent and aim to return surplus profits to their policyholders who, broadly speaking, replace shareholders as owners. Most mutual companies specialise in insurance for certain industries and claim, as a result, to make their policies especially suitable for members, knowing the needs and problems of the industries for which they cater. In Great Britain farming has its own mutual insurance society which is the largest agricultural insurance organisation in the world.

Apart from insurance companies there is Lloyd's. Best known as insurers of ships and cargoes, Lloyd's, briefly, is an association of persons who are grouped into some hundreds of "syndicates," for each of which an underwriter acts in the Lloyd's building. An insurance placed at Lloyd's is deal with by an insurance broker who usually prepares the polic and receives a commission on the premium. The policy show which syndicate or syndicates have agreed to take the insurance (in a large case it may be a dozen or more) and what fractio of the syndicate's proportion of the insurance each membe personally bears. Lloyd's underwriters are non-tariff.

First Considerations—Important though variations in premiums and scope of benefits may be, their importance may b assessed only when full consideration has been given t financial stability, reputation for proper claims settlement and the service that a company's staff and agents are willin and able to give.

Supposing a farmer arranges to take over a farm and wishe to effect the necessary insurances or, being insured, wishes t change his company. When satisfied about the financia stability and claims service of the company with whom h intends to insure he should consider the scope of the policie issued and their cost. Such questions as what insurance i essential ; what cover the various policies give and how fa short it falls of what is necessary ; the relation between cove and its cost ; and to what extent economies are justified, mus be faced.

Effecting an Insurance—All important insurance companie have offices in most parts of the country with a large numbe of full-time or part-time agents. A salaried "inspector works with all the agents in an area and a farmer ma deal with him or with an agent. A proposal form must b completed and signed by the farmer (the "proposer" The form is usually in two parts—the prospectus, describi the insurance and giving details of cover and cost ; the propos form proper, in which the proposer states what cover h requires and gives details of himself and his previous insuranc "history." It is legal to sign a proposal that has been com pleted by another person but better to do the whole thi one's-self. It is important (*a*) thoroughly to understand th questions and the replies given (*b*) to answer each questio fully and not to put in dashes or ticks as replies (*c*) to give corre answers in all circumstances. The last is vital ; an incorre answer places one in the wrong from the start.

The proposal is sent to the insurance office and a cover no is issued to hold the proposer protected pending issue of th policy which arrives later and should be read throug immediately. At the end of each year a renewal notice sent requiring payment in advance of the yearly premium and in acknowledgment of the renewal premium a renewal receipt is issued, the current one being kept always with the policy. Should a policy be lost, a duplicate should be supplied free on request.

What Insurances to Have—There are few farmers who will not need all these: **Fire** (for crops, implements, livestock, etc., and for buildings if owner of farm); **Employer's Liability**; **Motor** (private car, lorry, tractor); **General Third Party**; **Householder's**; **Life.** Strongly recommended is **Foot and-Mouth Disease** (Consequential Loss) cover.

Other common insurances are **Storm, Tempest and Hail,** e.g., for owners of glass houses. **Foaling** and **Stallion** for horse breeders, insuring mares and foals against death (including foaling risks) and stallions against death or disablement. **Cattle** (Accident and Disease) mainly for pedigree breeders. **Transit and Show** for exhibitors of stock and horses, covering transit to and from, and risks whilst at, shows and sales. **Goods in Transit** for farmers who do cattle transporting, etc. **Personal Accident and Sickness** for those who work actively on their farms and whom incapacity would cause financial loss through having to hire extra help, etc.

Finally, there are a large number of more specialised policies, used where the necessity arises only occasionally or in unusual circumstances. A farmer requiring exceptional cover should apply to an insurance company specialising in agricultural business. Most reasonable risks are insurable.

Fire Insurance (Farming Stock) The proposal form contains a number of printed items, usually repeated in the policy: and, by the side of each, the proposer puts the amount for which he wishes to insure. One item covers growing crops, stacks of hay, corn and straw, manure heaps and all horticultural and market gardening produce; any of such property that is within 60 yards of a railway line is separately insured. Other items cover implements, machinery, harness, utensils, tools, etc.; dead stock such as coal, building materials, fuels, artificial manures, manufactured feeding stuffs; livestock; poultry, including eggs and chicks under heat; household goods. Some items (not those on livestock, implements and household goods) are marked "Subject to the Special Condition of Average." Most farmers do not understand this clause and, as it is most important that they should, an explanation follows.

Farmers often claim that, as agricultural produce is spread about the farm and cannot all be burned at once, the amount for insurance should be the greatest value at one place. Similarly, a man owning one house worth, say, £1,200, in each of 100 towns might contend that, as only one is likely to burn at a time, the whole—worth £120,000—ought to be insured at the cost of the cover for £1,200. Each house has its own potentialities for being damaged by fire, exactly as if each were separately owned ; and a policy for only £1,200 covering all the houses would bear an "average clause" stating that the proportion of any agreed damage that would be paid would be the proportion that the amount of insurance bore to the full value : so a claim could be paid in full only if the sum insured equalled the value. In farming, because the amount of produce at risk is low from, say, December to May, an allowance is made and the ordinary Average Clause does not apply. Instead, the special clause states if the sum insured equals **three-fourths** of the value any under-insurance will be ignored although the sum insured must be the limit of payment, of course. When, however, the insurance falls below three-fourths of the value the ordinary Average Clause operates in full. The effect can best be judged from this table dealing with three hypothetical fires :

No.	*Sum Insured.*	*Value.*	*Amount of Loss.*	*Amount Paid.*
1	£750	£1,000	£600	£600
2	£750	£1,000	£950	£750
3	£750	£1,250	£500	£300

In No. 1 the insurance just equals three-fourths of the value and the clause does not operate. In No. 2 the clause similarly does not operate but the sum insured is too small to pay the full loss. In No. 3 the sum insured is not equal to three-fourths of the value and therefore 750/1,250 (or three-fifths) of £500 only can be paid.

The proposal form should show all the important exclusions that will be in the policy and they should be noted. One of them is that loss of property through its own spontaneous combustion is excluded but it is possible to arrange with one insurance company for a hot haystack to be inspected and tested and, within the terms of the scheme, if the stack cannot be prevented from firing, it will be paid for. It is well worth trying to get this advantage.

The policy ought to cover, without extra charge, agricultural produce sent away for processing, e.g., corn to be cleaned, dried or ground, grass to be dried or pulverised.

In all good policies, stock is insured whilst at agistment. Note that lightning is included in fire policies and, for livestock, is much the greater risk.

Eggs in incubators and chicks in hovers are a heavy insurance risk when the heating is by oil. If they are not specially mentioned in the proposal form, enquiries must be made, as many companies refuse to insure them.

The sums proposed for insurance must be adequate and it is well to make sure that the policy does not contain a low limit of value for any animal or implement. It is advisable not to have the policy renewable at Michaelmas—most farmers do—a good time being May or June when arable acreages and prices are known, yields can be established and the amount of insurance revised if necessary when the renewal premium is paid. If the policy is renewable on 29th September or 11th October a serious fire early in September may find the sum insured, fixed eleven months earlier, to be disastrously low.

Fire Insurance (Buildings) All the buildings will be described in the policy with a note of the materials of which each is built. One amount is placed on each detached building and each block of buildings that all adjoin ; it is necessary to give this information to the insurance company unless a representative is sent to schedule the buildings. If one finds the policy has one amount on separate buildings (other than a house and its domestic offices) and that amount is not subject to average it is most likely the insurance company believes that they do adjoin and they should be informed of the true position.

Under-insurance on buildings is rife. To-day the great majority of farm buildings are not insured for half their values and farmers constantly suffer serious losses through it. Even at the high prices ruling for farms now, they commonly change hands for less than it would cost to erect the buildings. If a farm building or a cottage must be replaced care must be taken to insure for the proper amount. Only if a cottage is redundant or a rambling range can be replaced by a compact smaller building should the reinstatement cost be ignored.

In the case of a mortgage the mortgagee will require his interest to be noted in the insurance and he holds the policy. The insurance company will supply a duplicate copy free.

TABLE 199.

Rates—The following are typical approximate charges :

	per cent.		
	s.	d.	
Agricultural produce, implements and dead stock	6	0	i.e., 6s. per £100 sum insured.
Agricultural produce near railway line	8	6	
Livestock	2	6	
Poultry and eggs under heat ...	8	6	—12s. 6d.
Poultry and eggs not under heat	2	6	
Household goods	1	9	upwards according to construction of house.

	per cent s.	d.	
Houses and cottages brick or stone built and slated or tiled —	1	3	
Houses and cottages thatched —	5	0	upwards.
Farm buildings not thatched —	2	6	
Farm buildings thatched —	7	6	

Employer's Liability—The State has taken over the liabi the employer had under the Workmen's Compensation A but there remains the employee's rights against his mas at Common Law. (Common Law refers to the right that has against B if the latter's careless, wilful or negligent ac causes A loss or injury, irrespective of any statute.) Un the Workmen's Compensation Acts the employer was resp sible for all accidents at work, whether he was at fault or n but his liability was limited. At Common Law he must proved to have been negligent, but the amount of his liabi is quite unlimited. He may be negligent through doing so thing or through failing to do something, directly or throu one of his servants. For example, he may personally han a vehicle or tool carelessly ; he may order or permit an uns method of working ; he may supply, or be aware of a de in, a machine or in his buildings or premises. In addition, si the repeal of the Workmen's Compensation Acts, an emplo has been made responsible for the careless, wilful or neglig acts of one employee to another. Farmers should understa that their liability in this matter is great and growing.

The premium is based on the amount of wages paid in a ye The first premium is paid on an estimate for the coming y and at each renewal date the insured is asked to give a statem of wages paid in the past 12 months. If these exceed amount on which the policy is based an appropriate additio premium is paid ; if it is less a return of premium is ma Many farmers avoid trouble by asking their insurance age to refer to their accountants for these figures which is excellent idea.

A good policy covers, without extra charge, such work use of explosives to clear ground ; horse-breaking for o use ; building maintenance or repairs ; loan of men to ot farmers.

Rates—For all ordinary farm employees the rate is 2s. to 3s. per cent. on wages paid and this rate should include threshing, timber sawing and cutting done, even if for h so long as one is not an agricultural contractor. Dome servants are usually rated at about 1s. 3d. per head and cle and secretarial staff at 6d. per cent. on wages.

Motor Insurance (Private Cars)—It is well known that a mo vehicle may not be used on a public road unless there is orce, relative to it, a certificate of insurance. The term motor vehicle" includes a tractor or self-propelled implement f any kind and use on the road includes crossing under power om one gate to another. It is generally said that there must e a Third Party insurance in force, although a Third Party olicy usually gives more cover than the Road Traffic Acts equire.

What is a third party? An insurance policy is a contract etween two parties—the insurer (or company) and the nsured. Sometimes it covers the latter's liability to any erson to whom he may cause loss or injury and such a person en becomes the third party to the contract. A Third Party otor policy covers such liability: a Comprehensive policy overs also damage to the car and personal accident and medical enefits, etc. Unless a car is so old that an insurance company ill not give full cover a Comprehensive policy should always e taken. Some farmers have "Third Party Only" policies ecause, for damage to their cars, they "can always go for the ther man." That does not work when damage is done in e owner's absence or by a hit-and-run driver or where the ther man's fault cannot be proved. Similarly, it is inadvisable take the discount offered for "restriction of driving to sured only."

A Comprehensive policy should contain all these benefits. any do not.

1. Manslaughter Defence. Most farmers think that the rdinary legal defence cover includes defence against a man- laughter charge but it is, in fact, limited to proceedings in a ourt of summary jurisdiction—which does not deal with anslaughter cases. As the cost of defence against such a arge is likely to be heavy it is essential that the policy should early mention this cover.

2. Personal Accidents. This cover usually applies to the sured only. It should apply also to the Insured's wife or sband.

3. Medical Expenses. Loss of rugs and luggage. When ese are included the limits should be noted. It is possible obtain limits of 25 guineas and £25 (twenty-five pounds) spectively.

4. Trailers. Not only should the use of a trailer be per- itted, like the carriage of livestock and light goods in the car, ut the trailer itself should be insured against damage without tra cost.

Certain extensions of the personal accident benefits are tainable at extra cost.

Insurance companies are pleased to reduce premiums when e insured bears the first part of each claim, say, £5, £10 or more. It is a reasonable proposition to take, say, a £5 exces and worth considering. A reduction is given also for insuring two or more cars in one policy.

The renewal premium is reduced if no claim arises in th previous year. Some companies give 10 per cent. at firs renewal, 15 per cent. at the second and 20 per cent. at the thir and subsequent renewals, going back to 10 per cent. after a year without bonus. Some have a flat-rate bonus of 20 per cent. Very high no-claim bonuses are usually based on high premiums and a lost bonus of say 33⅓ per cent. means that nex year the premium goes up by 50 per cent., often to a surprising figure. This realisation often gives rise to some heart-searching when a claim for a moderate amount occurs.

Commercial Vehicles—Lorries, vans, etc., may be insure for third party risks only or comprehensively but in the latte case the only addition to third party insurance is cover fo accidental damage to the vehicles. There are two points t note.

The first point is that the motor vehicle policies issued b most reputable companies cover frost damage, which can b serious in radiators and cylinder blocks but the insurance is in operative unless reasonable precautions are taken. It is no generally thought reasonable to open one draining cock instea of two; or to open both and to walk away without ensurin that they are not quickly blocked by sediment; or to leave an vehicle—car, lorry or tractor—in an open shed in winter wi perhaps, a sack flung over the radiator.

The second point is that passenger liability must be covered Employees often give lifts to strangers, fellow workmen o friends, with or without their master's knowledge. The latte is liable for the consequence of any negligence and he mus therefore, be sure that his liability to non-fare-paying passenger is covered even if it costs a few shillings extra.

Tractors—Tractors are on a similar basis to commercia vehicles as regards third party and comprehensive insuranc but the use of trailers with tractors complicates the matte somewhat. Trailers are divided into two classes with optiona cover available at stated premiums, and in this respect th prospectus should be well studied.

Occasional hire work is allowed free but the insurance o contractors' vehicles costs rather more. If crop-spraying fo hire is done it is essential to make certain that the policy allow it. Passenger liability is important—it is difficult to keep childre off tractors and their trailers, especially at harvest time. I should not be necessary to pay an extra premium; but whe it is necessary it should be paid. As regards frost damage i is very easy, with tractors, not to take "reasonable precautions

Rates (Private Cars) The country is divided into five ing districts—A to E—of which only A (the lowest rated) d B and C generally affect farmers. In each district rates ry with horse-power and value. A few average premiums shown below ; they will be reduced by rebates for number cars insured, for taking an excess or by no-claim bonus :

TABLE 200.

P.	Value £	Place	Rating District	Premiums	£	s.	d.
	300	Wiltshire	A	Comprehensive	10	17	6
				Third Party only	4	17	6
0	500	Cambridgeshire	B	Comprehensive	14	2	6
				Third Party only	6	7	6
2	600	Yorkshire	C	Comprehensive	16	7	6
				Third Party only	7	2	6
5	1,000	Scotland—except parts of Lowlands	A	Comprehensive	14	17	6
				Third Party only	6	12	6

Commercial Vehicles—Rates in country districts are uniform t vary according to class of licence and carrying capacity. amples :

TABLE 201.

		£	s.	d.		£	s.	d.
" licence—								
cwt.	Comprehensive	9	15	0	Third Party only	4	17	6
cwt.	„	14	0	0	„ „	7	0	0
tons	„	17	17	6	„ „	11	12	6
B " licence—								
tons	„	27	5	0	„ „	16	2	6
A " licence—								
tons	„	97	0	0	„ „	42	10	0

TABLE 202.

Tractors	Comprehensive	Third Party only
sed only by farmers, etc., for agricultural purposes only ...	1 15 0	12 6
sed by agricultural contractors	2 10 0	15 0
pedestrian-controlled	1 0 0	7 6

General Third Party—Innumerable cases can be quoted ustrating the need for this insurance. One wet day a ry delivers meal at a farm. Suddenly a youth on the ry screams and dies ; removal of the load had caused the rings to lift the lorry and the metal can had touched bare erhead cables, of which the farmer had failed to give warning, d the boy was electrocuted.

A farm-hand leaves a field gate open whilst catching a
a child wanders in and is fatally kicked. A dairy farmer
to mend a cowshed roof; a tile slips and severely
caller. A fire lighted to burn-off stubble spreads and de
a neighbour's stacks. In all these cases negligence res
the farmer, because anybody who carries on a busine
responsible at law for all loss, damage or injury caused thr
the negligent or careless carrying on of his business.
can the farmer protect himself?

It is true that most insurance companies have rather negle
agriculture in this matter and offer farmers policies draw
for ordinary commercial risks but there are one or two
cater specially for farmers. It is possible to obtain a
comprehensive policy covering all third party risks and
addition, accidental fatal injury to animals and accide
damage to implements, all at a reasonable premium. Th
policies are very popular with farmers but it is emphasised
they are not obtainable from the majority of insurance comp
This is a resume of a typical specialised policy :

1. CLAIMS BY THE PUBLIC through
   - use of horses or horse-drawn vehicles or implements ;
   - use of hand-drawn vehicles or pedal cycles ;
   - livestock being driven or straying ;
   - any negligence of the Insured or employees ;
   - defects in any buildings, plant or machinery ;
   - carriage of non-fare-paying passengers in horse-drawn vehicles ;
   - fire negligently caused.

   Plus a
   legal c
2. EMPLOYER'S LIABILITY INSURANCE plus legal costs.
3. LEGAL LIABILITY TO REPLACE NATIONAL HE
   INSURANCE STAMPS if lost through any cause.
4. FATAL INJURY TO LIVESTOCK by accident, incl
   conveyance by motor vehicle.
5. ACCIDENTAL DAMAGE TO VEHICLES, HARNESS
   IMPLEMENTS.
6. PERSONAL LIABILITY to the public through sp
   pastimes and any private activities.
7. SHEEP WORRYING BY DOGS.

Many companies limit their third party cover, as to
amounts to be paid for any one claim and in any one
This must be avoided and unlimited third party cover is esse
Suppose a horse, negligently handled, caused a motor
to overturn, thus killing and injuring most of the occu
how far would a farmer be protected by an indemnity
say, £5,000 ?

hen it is not possible to obtain all the above cover, every rt should be made to secure at least the whole of the third y cover in respect of claims by the public.

ates—Third party risks are rated on wages, acreage, or mbination of both. Indications of what must be paid to r third party liability on farms of various sizes are :

	£	s.	d.
25 acres and £750 wages	1	10	0
100 acres and £1,500 wages	1	15	0
300 acres and £3,000 wages	3	10	0
500 acres and £10,000 wages	6	10	0

over for livestock is usually charged at a quite nominal on the value of stock on the farm or maximum value on road at a time. For accidental damage to vehicles it is ally based on wages or number of drivers. Sheep worrying miums are based on values of stock.

ouseholders' Insurances' Contents—Householders' Comhensive policies (sometimes given names like "All-in cy") have been deservedly popular because they are most venient and extremely good value. Where the construction he house allows comprehensive cover to be given, this n of cover is certainly recommended.

Most people know that these policies cover the chief risks concern a householder, including especially fire, burglary storm and tempest, the normal premium for which alone uld almost equal that of a Householders' Comprehensive cy.

he many other benefits, including breakage of mirrors, idents to servants and bursting of water pipes cannot all be cribed here but farmers should study several propositions ore making a choice since one or two weaknesses in many licies are avoided by a few companies who cater for agriulture. For instance, it is common to require the policyholder bear the first £5 of claims through certain causes and, if sible, this should be refused. It is important, too, to see the policy specifically covers the policyholder's liability a private person, whilst playing games and sports, whilst ing, etc. The latter is often omitted.

ates—Premiums are calculated on the sum insured which uld be the full value of the contents (any policy containing average clause should be refused) and rates are 5s. per cent. ards according to how the construction of the house affects fire risk.

uildings—Houses and domestic offices are commonly ured for fire only but, for a very little more, other important risks such as storm and tempest, bursting of pipes and overflowing of tanks, aircraft, impact by road vehicles and loss of rent may be added. Comprehensive cover is recommended where the construction of the house allows it to be given.

When studying prospectuses the requirement to bear the first £5 should occur as rarely as possible.

Rates—A number of alternative schemes are offered and a prospectus should show clearly what risks each scheme covers. Premiums are based on the value of the house and range, for the widest cover, from 2s. per cent. upwards.

Foot and Mouth Disease (Consequential Loss)—Confirmation of the existence of foot-and-mouth disease on any farm means immediate slaughter of all cattle, sheep and pigs and the closing of the farm by Government order for about six to eight weeks. The Government pays the stockowner the market value of the destroyed animals. That does not recompense the farmer for heavy financial losses through having to pay wages to employees who cannot be dismissed, loss of profit on milk, wool and other produce, loss of markets and milk rounds, cost of rebuilding herd or flock, continuation of overheads such as rent, personal expenses and so on.

A policy to cover this risk should not be expensive and it is a sound investment. The insurance is usually for a given percentage, say 25 per cent., of the value of the stock or of the amount paid by the Government as slaughter compensation; it should be possible to insure different kinds of stock for different percentages, e.g., 25 per cent. on cattle and 15 per cent. on sheep. It should not be necessary to give separate values on different kinds of cattle nor to state the numbers of animals. The policy should not contain a waiting period—cover should begin immediately.

Rates—Some companies insure only cattle; others cover all animals. The lowest rates, to pay 25 per cent. of Government compensation, are about 1s. 3d. per cent. (on value of stock) for sheep and 2s. 6d. per cent. for cattle. Pigs, especially on pig farms, cost a little more.

Life Assurance—For any man in average good health there is no better investment than a life assurance.

The income tax rebate on premiums, the fact that payment of the sum assured and its bonus additions is untaxed and the investment facilities of life assurance companies combine to give the policy holder an excellent financial return when the policy matures, with very much greater profit to his estate should he die earlier.

In life assurance the policyholder pays a level premium at regular intervals and on the happening of a certain "event" the company pays the agreed sum, plus bonus additions, or "profits," which vary with the trading results of the company during the policy's currency. (Non-profit policies are cheaper but are not recommended.) In whole-life policies the "event" is the Life Assured's death; and premiums are paid throughout life or for an agreed period. In endowment assurance the "event" is expiry of a given number of years or death, whichever occurs earlier and premiums are paid until then. Rather more assurances are endowments than otherwise.

After payment of two or three years' premiums most policies acquire a "surrender value" when, if desired, a policy may be discontinued and the surrender value (a relatively small proportion of the premiums paid) may be taken. To surrender a policy should be the last resort and the alternative, a "paid-up policy" should be taken. In this, although no further premiums are paid, the policy continues until the "event" and the sum then paid is the proportion of the original sum assured that the number of premiums paid bears to the total number originally payable. For example, a £3,000 endowment policy issued for 15 years could be converted, at the end of five years, to a policy for £1,000, no more premiums to be payable. Some profits would be added.

Most policies can be issued under the provisions of the Married Women's Property Act, 1882 and an intending insurer should require this to be explained to him thoroughly. Briefly, the advantages are: (1) on the death of the Life Assured his widow may be paid within a few days and without waiting for grant of probate which usually takes weeks and may take years; (2) any operation on the policy (e.g., surrender) needs the signature of the Life Assured and his wife. A farmer encountering serious trading difficulties may find that his creditors will take a policy in the usual form and surrender it for a small sum; whereas, with one issued under the provisions of the Married Women's Property Act, if the wife is not a partner in the farm she may refuse to sign a request for surrender and the policy may be safeguarded for their joint personal interest—at worst a paid-up policy could be taken. Note that difficulties in connection with the necessity for this double signature may arise (i) if husband and wife become estranged, (ii) if either party should become insane.

One should not effect a life policy without having expert advice from an official of a reputable company. In no other kind of insurance are the pitfalls less obvious and as, broadly, the terms of a life assurance cannot be altered after issue, one must be sure to effect exactly the kind of assurance that one needs.

The following are a few of the many types of policy that are available.

Family Policy (marketed under several similar names Typical benefits : on death within 20 years of effecting policy £312 a year *tax free*, for the balance of the 20 years and then £2,000 in cash ; on death after the first 20 years, £2,000 in cash To each of these sums profits would be added—anything from £400 to £1,000 in the latter case. Cost : for a man rising 40 about £78 a year.

Pension Policy (a comparatively recent innovation) Typical benefits : at age 65, £150 a year for life, *tax free* at least to age 80 ; at death £2,250 less any pension payments that may already have been made, plus bonuses. Cost : at rising 30 about £63 a year ; at rising 40, about £90 a year.

Child's Protection Policy (recently marketed in improved form) Premiums begin preferably in infancy. When the child is 21 it is offered, *irrespective of state of health*, the choice of a cash sum or of policies maturing at varying ages with o without continuation of premiums ; alternatively, a cash sum may be taken earlier for education. Such a policy should provide that if the selected parent dies before the child is 2 no further premiums are required until that age is reached when all options are offered in full. This improves the protection greatly and makes the premium rank for income tax rebate. Many policies are offered without this cover Premiums are usually quoted at round figures—say, £10 a year– and the benefits adjusted accordingly.

Education Policies—These are usually endowment assurance on the life of one parent, providing, at the end of the agreed term or previous death, the sum assured in cash or a slightly larger sum if spread over, say, five years. Better value can be obtained if the majority of the sum assured is not payable until the end of the agreed period whether the parent's death occur earlier or not—the money is not normally wanted until the child has reached a certain age.

Income Tax Rebate—Broadly, the premium paid fo assurance on the taxpayer's life or on that of his wife ranks fo income tax relief. Only the first £7 per cent. of the premium is counted, which means roughly that if the term of the assurance is less than 15 years not all the premium ranks for relief. There are other limitations and regulations which may vary from time to time and which should be explained fully by an official o the company to whom one proposes ; the general effect is however, that income tax is reduced by approximately one-sixth of the amount of premium paid.

Medical Examination—Most large companies are now willing to dispense with medical examination in any normal case where a reference to the proposer's doctor and to two friends proves satisfactory; there are, however, usually these limits: amount of assurance £2,000, age of proposer 50. The company pays for what medical evidence is required in normal cases.

Premium Payments—The majority of companies are willing to take monthly payments of one-twelfth of the annual premium; the payment must be by banker's order and receipts are not given. Monthly premiums are admirable. They enable a farmer, especially the young farmer, to take out life assurance at the proper time—as early as possible and as often as possible.

Claims—The best time to begin dealing with every claim is before it occurs—in fact, when the insurance is effected.

It does not pay to economise on premiums by cutting down the amount of cover. To insure reasonably generously helps to take care of any increase in value, or risk, that may go overlooked. One should never sign a proposal form un-read no matter how much one trusts the agent. The policy should be carefully read on receipt, returned for alteration if necessary and then kept in a safe place.

Renewal premiums should be paid promptly; to have all the policies renewable on the same day is an advantage and insurance companies will gladly co-operate.

Insurance is impossible without good faith on both sides and one must be able to trust the company in every reasonable way. If this is not possible, a move is indicated; but it is not advisable for the company to hold similar ideas about the Insured.

When any possible cause for a claim arises—even if not an immediate claim—the policy should be read carefully and the instructions followed. If an animal is thought to be struck by lightning, for instance, the company must be informed by telephone or telegram and allowed to see the carcase. If one is involved in a motor accident one must be quite sure to take the name and address of any witness and not to make the slightest admission of any liability.

If any considerable difficulty arises between the company's assessors and the Insured as to the amount to be paid or some similar matter, the "arbitration condition" in the policy should be studied. The assessors will usually be an independent firm, employed by many insurance companies and will hold no brief for the particular company for which they are acting. If they inform the insurers that one is entitled to less than is claimed, there will be a reason. Once again, if one dea reasonably with the insurers they will deal reasonably in tu It practically never pays to tell them " Pay my claim in full o I take my insurances away "—they will probably acquiesc On the average, an insurance company's profit is two or thre per cent. of its turnover so by paying, say, £100 extra on a claim they are forfeiting the profit on premiums of perhap £4,000—rather more than the ordinary farmer pays in a lifetime.

Future Trends of Insurance.—These are some of the change that may be expected to come in the next few years.

Insurance rates will probably increase. Except for moto insurance they are virtually the same as in 1939. So far a agriculture is concerned rates for fire insurance may rise unles there is a sequence of wet summers or unless insurance companie are content to continue making losses on this class of insurance The alternative is to exercise more care on the farm becaus statistics show clearly that most farm fires occur through carelessness, the most culpable being the lighting, without takin adequate precautions, of fires to destroy threshing rubbis clamp bottoms, hedge trimmings, straw left by combines, etc Rates may be increased for produce growing near railwa lines and they are steadily rising now for thatched buildings especially when in the majority on a farm. Farms near larg towns are bad fire risks; farmers know this and will not b surprised at any premium increase.

Claims by workmen under Employer's Liability insuranc have proved to be numerous and the awards in contested case are high and still increasing. It is thought that increases i premium rates are inevitable and that they may be substantial

Awards to third parties have sharply increased in moto insurance during recent years and this, together with the eve rising cost of motor repairs, has brought an increase in rates effective from 1st June, 1951. It is felt, too, that there ma inevitably be a further rise in the comparatively near future Farmers may, however, reasonably hope for special treatmen then; country risks are already much lower-rated than tow vehicles but the difference between the two may be eve greater when premiums are increased again.

A tendency that will be welcomed by most farmers is tha of putting more risks into one policy so as to reduce the numbe of documents necessary for complete cover. Several companie are beginning to do this, especially those specialising in far insurance. It is probable that other companies will begin t explore the agricultural market—there are already signs tha some are interested. On the whole they will offer the farme ood security and normal premiums. The service that they an give to their policyholders in scattered country districts nd the scope of the cover in their farmers' policies is, perhaps, ot so certain.

Farming practice, especially as it may affect insurance, is hanging continually. For instance, the increase in mechanisation is at present tending to produce more fires and more ccidents and the introduction, as weedkillers and insecticides, f some very toxic and dangerous compounds is causing roblems of magnitude. These and other problems may put experienced companies in some difficulties but a small number f insurance organisations with wide and established agricultural connections will be able to adjust their practice in the ght of modern developments.

Nationalisation of the insurance industry has been at least eferred in favour of proposals for "mutualisation." These roposals may be put into force and, if they are, the whole f the insuring public will be affected if only because of the robable loss of the benefits that arise through competition. t seems likely that, should this take place, agriculture may be ss troubled than most industries because its specialising nsurance society is already fully mutual and, therefore, not kely to be affected by the Government's plans.

MENSURATION—Mathematical and other Signs

= signifies "equal to."
„ "added to" (*plus*).
- „ "subtracted from" (*minus*).
× „ "multiplied by."
÷ „ "divided by."
^{2}, b^2, etc., signifies *a* or *b* "squared" (× itself).
signifies "square root of."
F. or ° C. signifies degrees Fahrenheit or Centigrade.
signifies angle.
„ degrees of ∠.
„ minutes „ ; also feet.
„ seconds „ ; also inches.
% „ per cent.

GUNTER'S CHAIN—Measuring is done by this chain, which 66 ft. long (4 rods), divided into 100 links, each 7·92 in. n acre is 100,000 square links, and the chain is therefore a onvenient standard for land measuring.

COMPUTATION OF ACREAGE—Divide the enclosure into onvenient triangles; multiply the base (in links) of each iangle by its perpendicular height, and divide by two; this ves area in square links; point off five figures to the right

(=dividing by 100,000 the number of square links in an acre). gives acres and decimal fraction. Repeat the process for each triangle, and add together. Multiply decimal fraction by 4, point off 5 figures leaves roods : multiply fraction left by 40, point off 5 figures leaves poles and decimal fraction.

Area of each of these triangles is=

$$\frac{\text{base} \times \text{perpendicular}}{2} = \frac{A\,B \times C\,d}{2}$$

Let S = ½ sum of sides of any triangle ;

$$= \frac{A\,C + C\,B + A\,B}{2};$$

then

$$\text{Area} = \sqrt{S\,(S - A\,C)\,(S - C\,B)\,(S - A\,B)}.$$

In right-angled triangles :—

Hypotenuse = $\sqrt{\text{base}^2 + \text{perp.}^2}$;
Base ... ... = $\sqrt{\text{hypot.}^2 - \text{perp.}^2}$;
Perpendicular = $\sqrt{\text{hypot.}^2 - \text{bases}^2}$

PROPORTIONAL MEASURES

Area of square = any side × itself.
„ rectangle = length × breadth.
„ parallelogram = base × perp. height.
„ circle = diameter² × ·7854.
„ „ = radius² × 3·1416.
„ „ = circumference² × 0·0796.
„ „ = circumference × diameter ÷ 4.
„ „ = radius × diameter × 1·57.
„ sector of circle = length of arc × ½ radius.
Circumference of circle = diameter × 3·1416.
„ „ = radius × 2 × 3·1416
„ „ = square root of area × 3·54.
Diameter „ = circumference × 0·3183.
„ „ = square root of area × 1·1283.
Radius „ = circumference × 0·1591.
„ „ = square root of area × 0·564.
„ „ = diameter ÷ 2.
Side of square in circle = diameter × 0·7071.
„ „ = „ = diameter × 0·8862.
„ „ = „ = circumference × 0·2821.
Length of arc = degrees × radius × 0·01745.
Surface of cylinder = area of both ends + length × circumference.
„ cone = circumference × ½ slant height + area of base.
„ sphere = diameter² × 3·14159.

Solid content of cylinder = area of one end × length.
" " sphere = diameter^3 × 0·5236.
" " cone or pyramid = area of base × 1/3 perpendicular height.
" " wedge = area of base × ½ perpendicular height.

TO SET OFF A RIGHT ANGLE WITH THE CHAIN ONLY—Measure off 40 links on the ground along the base-line; then take 30 for the perpendicular, and 50 for the hypotenuse; by fastening the extremities of these last 80 links at the ends of the base, and pulling the chain tight, we have a right-angled triangle.

INACCESSIBLE POINTS

1. Start from A (exactly opposite to E) and go to B; continue to C, making B C = A B; erect C D perpendicular to A C, and find D in a line with B and E; C D = A E.

2. Take B A at right angles to C D; draw A C perpendicular to A D; then A B : B D :: C B : B A.

OBSTACLES IN CHAINING LINES

1. If the obstacle can be seen over:—Erect two perpendiculars (A C and B D) of equal length at A and B; then C D = A B.

2. If the obstacle cannot be seen over:—Lay off A C and E F, equal to one another, and at right angles to A F; range the points D and H in line with E C, and set off D B and H G at right angles to E H, and each = E F or C A; then C D = A B, and B and G are points for ranging the continuation of F A.

TO MEASURE THE AREA WHERE BOUNDARY IRREGULAR.

Lay off a base line, A G, and measure offsets to the various bends and angles of the boundary line, and at right angles to the base: this divides the enclosed space into approximate triangles and trapezoids. The area of the triangles is calculated in the usual way; for the trapezoids the average of the two sides is taken and multiplied by the base: thus, area

$$BCJH = \frac{BH + CJ}{2} \times BC;$$ and similarly for the rest:

the sum of the whole = area of A G M K H.

TO SUBSTITUTE A STRAIGHT LINE FOR A CROOKED BOUNDARY SO AS TO EQUALISE THE TWO SIDES

From a starting point A, lay off an assumed line A C as near to the true one as can be guessed. Find the areas of the "loops" on one side against those on the other: divide twice the difference by the length of the trial line, and the quotient will be the distance from C to B, so that A B will divide the sides equally.

DIMENSIONS OF AN ACRE

An acre laid out as an exact square must have its s made 316·23 links = 208·71 ft. = 69·57 yards ; it may be ta at 70 steps.

Ordnance Survey Notes

Scales. 1/63360 = 1 in. to mile for the kingdom.
1/10560 = 6 ,, ,, ,, counties.
1/2500 = 25·344 ,, ,, ,, parishes.
1/500 = 10·56 ft. ,, ,, towns.

The "25-inch scale" is the most useful for farm purpos on this a square inch is a very near approximation to an a

Levels—The datum from which all heights are calcula is the average of the tides at Newlyn, Cornwall. The heig in feet are marked on the Ordnance maps at every B ("bench mark"), and the "broad arrow" sign to corresp will be found on buildings, walls, gateposts, etc.

Contours—Contour lines begin at the 50-ft. line above m sea level, and are shown at every succeeding 100 ft. They entered on the 1-in. and 6-in. maps only.

Estimation of Contents of Stacks, Silos, Clamps and Dutch Ba

1. (*a*) If **rectangular**, multiply length by breadth by heigh
   (*b*) If **circular**, multiply circumference by itself and by
   and then by height.
   (*c*) If **triangular prism**, multiply length by breadth at b
   and then by half the height.
   (*d*) If **cone**, multiply circumference at base by itself
   by ·08 and then by ⅓ the perpendicular height.

FOR STACKS

2. Add (*a*) and (*c*) or (*b*) and (*d*) together : result will be c tents in cubic feet if measurements taken in feet.
3. Reduce to cubic yards by dividing by 27.
4. Reduce to tons by dividing by one of the following numb according to the shape and condition of the stack :—

	No. of cu. yds. per t	
HAY—	Rectangular	Rou
If not settled	12	13
If fairly settled	10	11
If compact	8	9

STRAW—

Number of cubic yards per ton :—

Wheat	18–20	Oat	20–23	Barley	20

ROOTS—

Weight per cubic foot in clamp :—

Turnips, 33 lb.	Mangolds, 35 lb.	Carrots, 31 lb.
Swedes, 34 lb.	Potatoes, 42 lb.	Parsnips, 31 lb.

SILOS—A cubic foot of grass silage weighs on an average 40

A pit silo, 14 ft. wide at surface, 3 ft. deep and 12 ft. at the se, will hold 5 tons of silage per yard of length.

A circular silo will hold 100 tons of silage for every 5,300 bic ft. of space.

THATCH—Thatch on Stacks, etc., is measured per square 100 square feet. For oblong stacks the length of eaves ultiplied by length over ridge from eaves to eaves is taken. or round stacks the thatch is measured as a cone; the cumference round the eaves multiplied by half the length slope of top. For round ended stacks the measures are ken as for an oblong + two half cones, or length of one aight eaves plus half round one end × measure over ridge om eaves to eaves.

CARTS—For measuring the contents of carts, dunghills, oneheaps, etc., the same rule is used as that for the prism dy of a stack. In practice the average or middle length, eadth and depth are taken as being near enough.

GRAIN—For measuring grain in the heap, take the cubic ntents in feet and multiply by ·8 to give bushels. A cubic ot is 1,728 cubic in., and a bushel 2,219·7 cubic in., or as to 1·285; that is, as ·778 (say ·8) to 1. In practice 4 bushels ual 5 cubic ft.

3·64 c. ft. New Oats = 1 cwt.
2·38 „ „ Barley = 1 „
2·20 „ „ Wheat = 1 „

For grain in stack the usual proportions are :—

	Cub. ft. to 1 bushel	Weight of straw to 1 bushel lb.
Wheat	27	112
Oats	18	61
Barley	22	62
Peas	36	87
Beans	35	98

IRREGULAR HEAPS—For measuring irregular heaps of dung, rthwork, clinkers, etc., divide the surface into convenient angles, take the depth of each triangle at its average point ther by probing-iron or by levelling from adjacent ground el) and calculate each triangle on its own area.

Farmyard Manure : Measurement and Application

FARMYARD MANURE—One cubic yard of farmyard manure ighs 12 to 16 cwt., or 1 ton of farmyard manure bulks 1¼–1½ bic yards.

APPLICATION OF FARMYARD MANURE—

1. Heaps 10 yards by 10 yards — 50 heaps per acre approx.
2. „ 5 „ „ 10 „ —100 „ „ „
3. „ 5 „ „ 5 „ —200 „ „ „

200 heaps per acre :—

Weight of heap cwt.	Weight per acre tons
½	5
¾	7½
1	10
1½	15
2	20

TABLE 203—Present and Obsolete Standards.

Acre :—		
Imperial	4,840·0 sq. yds.	1·000 Imp.
Scottish Standard	6,104·128 „	1·26118 „
Cunningham	6,250·0 „	1·291 „
Dumbarton	6,084·444 „	1·257 „
Inverness	6,150·4 „	1·270 „
Irish Plantation	7,840·0 „	1·61983 „
Northumbld. and Durham	5,926·58 „	1·224552 „
Westmorland	6,760·0 „	1·396 „
West Derby	9,000·0 „	1·859 „
Lancashire	7,865·968 „	1·6252 „
Cheshire and Staffs	10,240·0 „	2·1157 „
Leicestershire	2,308·75 „	0·477 „
Herefordshire	3,226·66 „	0·666 „
Wilts and Dorset	3,630·0 „	0·749976 „
Devon and Somerset	4,000·0 „	0·8264 „
Cornish	5,760·0 „	1·1901 „
N. Wales (customary)	3,240·0 „	0·669 „
„ (Erw)	4,320·0 „	0·892 „
Woodland	5,760·0 „	1·1901 „
French " Hectare "	11,960·3326 „	2·4711431 „
„ " Are "	119·6033 „	0·0247 „
Belgian " Hectare "	11,960·3326 „	2·4711 „
Prussian " Morgen "	3,053·0 „	0·630 „
Rhine „	10,185·0 „	2·1043 „
Hamburg „	11,505·0 „	2.377 „
Amsterdam „	9,722·0 „	2·0086 „
Acreme (old)		10 acres.
Anker	Liquids	10 gals.
Are	100 square metres	1,076 sq. ft.
Aume	Dutch	40 gals.
Aune (old)	French ell	45, 47, 54, 68 in.
Beans	Barrel	280 lb.
Barley	„	224 „
Barony of Land	40 hides	4,000 acres.
Barrel	Beans	280 lbs.
„	Barley	224 „
„	Bulk	5 cub. ft.
„	Old Ale Measure	32 gals.
„	Old Beer	36 „
„	Ale and Beer (Imp.)	36 „
„	Apples (126, 140 or)	120 lb.
„	Herrings	500.
„	Butter	224 lb.
„	Soft Soap	256 „

TABLE 203—(*contd.*)

Beef	Firkin	100 lb.
,,	Barrel	200 ,,
,,	Tierce (38 pieces of 8 lb. each)	304 ,,
Boll :—		
Wheat	Berwick, etc.	6 bushels.
,,	Glasgow, etc.	4 ,,
,,	,, ,,	240 lb.
,,	Hamilton	240 ,,
,,	Newcastle, Carlisle	3 bushels.
Barley	Linlithgow	0·728 qr.
Oats	Ayrshire, etc.	8 bushels.
,,	Glasgow	6 bushels, each 44 lb.
Oatmeal	Ayrshire, etc.	140 lb.
,,	Galloway	280 ,,
Ryegrass Seed	96 lb.	4 bushels.
Old Boll—Corn	4 " bushels "	8 ,, Imp.
,, —Salt	2 ,,	4 ,, ,,
Bovate	⅛ carucate	14 acres.
Bricks	Load (cu. yd.)	500.
Bristles	Cask	10 cwt.
Broccoli	Sack	60 to 70 lb.
Bunch	Carrots	36 to 40.
,,	Turnips	20 to 25.
Bundle	Asparagus	100 to 150.
,,	Broccoli	6 to 20.
,,	Rhubarb	20 to 30.
Bushels :—		
Imperial	1·28 cub. ft.	8 gals.
Carlisle		24 ,,
Cornish		24 ,,
Irish		7·85504 gals.
Staffordshire	38 qt.	9·5 gals.
Winchester		7·75557 gals.
Wheat	Standard	62 lb.
,,	Mark Lane	60 to 63 lb.
,,	Aberystwyth	65 lb.
,,	Birmingham, etc.	62 ,,
,,	Chester, etc.	75 ,,
,,	Wolverhampton	72 ,,
,,	Liverpool, etc.	70 ,,
,,	Monmouth, etc.	80 ,,
Butter	Firkin	56 ,,
,,	Roll	24 oz.
,,	Tub	84 lb.
,,	Barrel	224 ,,
,,	Dutch Cask	112 ,,
Butt or Pipe	Scots	120 gals.
Cable Length	120 fathoms	720 ft.
Cade	Red Herrings	500.
,,	Sprats	1,000.
Carat	Jewellery	3·2 grains troy.
Carucate	1 year's ploughing	112 acres (8 oxgangs).

TABLE 203—(*contd.*)

Case	Apples	40 lb.
,,	Onions	120 lb.
Cental or Quintal		100 lb.
Chain	22 yards	66 ft.
Chalder	Corn	8 qr.
Chaldron	Coals (London)	36 bushels.
,,	,, ,,	25½ cwt.
,,	,, (Newcastle)	53 ,,
,,	Corn	4 qr.
Cheese	Clove	8 lb.
,,	Stone	16 lb.
,,	,, (Scotland)	24 ,,
,,	Ordinary Wey	250 ,,
,,	Suffolk ,,	256 ,,
,,	Sussex ,,	336 ,,
,,	Essex ,,	416 ,,
Chopin	Liquid	1·5 Imp. pint.
Cider	Pipe	100 to 118 Imp gals.
Clove	Wool	7 lb.
Clover Seed	Sack	2 to 3½ cwt.
,, ,,	Cask	7 to 9 ,,
Coal	Chaldron	36 bushels.
,,	,, (Newcastle)	53 cwt. = 3 wains.
,,	Barge	21 tons.
,,	Keel (8 chaldrons)	21 tons 4 cwt.
,,	Shipload	20 keels.
,,	Wain	17·6 cwt.
,,	Ton	10 sacks.
,,	Sack	224 lb.
,,	Room	7 tons.
Coomb		4 bushels.
Cubit	21·88 in. or	18 in.
Cwt.	Imperial	112 lb.
,,	American	100 ,,
Digit		·91 in.
Ell	English	45 in.
,,	Scottish	37·0598 in.
,,	French	54 in.
,,	Flemish	27 ,,
Faggots	" Hundred "	120.
Farundale or Farding-Land (old)		¼-acre.
Feathers	Bale	1 cwt.
,,	Last	17 ,,
Firkin	Butter	56 lb.
,,	Imperial	9 gals.
,,	Soft Soap	64 lb.
Firlot	Scottish Standard	1 Imp. bush.
,,	Wheat	0·998256 ,,
,,	Barley and Oat	1·4562794 ,,
Fish	Box	90 lb.
Flax	Last	17 cwt.
,,	Dutch Matt	126 lb.
,,	Flemish ,,	224 ,,
,,	Russian ,,	5 to 6 cwt.

TABLE 203—*(contd.)*

Flax Seed	Riga Barrel	4 bushels.
,, ,,	Dutch ,,	8 ,,
Flour	Gallon	7 lb.
,,	Peck	14 ,,
,,	Bushel	56 ,,
,,	Barrel	196 ,,
,,	Sack	280 ,,
,,	Load or Pack	240 ,,
Gallon :—		
Imperial	277·463 cub. in.	1·0 Imp. gall.
American	231·0 ,,	0·833 ,,
Old Barn or Winchester	268·8013 ,,	0·96944 ,,
New Barn	589·203 ,,	2·125 ,,
Old Wine	231·0 ,,	0·83311 ,,
,, Ale	282·0 ,,	1·01705 ,,
Scottish	833·6272 ,,	3·00651 ,,
Irish	217·6 ,,	0·78478 ,,
Gawn or Goan (old)		1 gall.
Glass	Seam	120 lb.
,,	Stone	5 lb.
Gramme	0·035 Avoir. oz.	15·432349 gr.
Gross		144.
Guano	Bag	1½ cwt.
,,	Bushel	60 to 70 lb.
Hand		4 in.
,,	Radishes	12 to 30.
Hay	Bale	2 cwt.
,,	Load	36 trusses.
Old Hay	Truss	56 lb.
,,	Load	18 cwt.
New Hay	Truss	60 lb.
,,	Load	19 cwt. 32 lb.
Hectare	11,960·3326 sq. yd.	2·4711431 acres.
Hectostere	100 cub. metres	130·802 cub. yd.
Hemp	Stone	32 lb.
,,	Bale	10 tons.
Herrings	Cade	500 lb.
,,	Barrel	26·66 gals.
,,	Cran	37½ ,,
Hide of Land	Standard = 70 acres = 5 " yards "	60, 70, 80, 100, or 120 acres.
Hides	Dicker	10 skins.
,,	Last	20 dickers.
Honey	Gallon	12 lb.
Hoop (old)		1 peck.
Hops	Bag	2¼ cwt.
,,	Pocket	1½ cwt. (13 = ton).
Kainite	Bag	2 cwt.
,,	Bushel	75 to 80 lb.
Keg	Herrings	60 (two = " hundred ").
Kemple	Straw	440 lb.
Kilometre	1,000 metres	1,093·633 yd.
Kilogramme	1,000 grammes	2·2046 lb. Av.

TABLE 203—(*contd.*)

Kilolitre	1 cub. metre, or 1,000 litres	220·09667 gals.
Knight's Fee	7 Hides	490 acres.
Knot	Admiralty	2,026·66 yards.
"	Geographical	2,027·55 "
Last	White Herrings	12 barrels.
"	Red "	20 cades.
"	Corn	10 qr.
"	Wool	12 sacks.
"	Leather	20 dickers.
"	Flax or Feathers	17 cwt.
"	Gunpowder	24 barrels (2,400 lb.).
"	Meal	12 barrels.
Leap, or Lip (old)		½ bushel.
Linen (Irish)	Piece	25 yards.
Link		7·92 in.
Lispund	Scots	1/15 of barrel = 13·1 lb.
Litre	1·76 pints	0·22 gal.
Load :—		
Bricks		500.
Coals	Scots	1 cwt.
Flour		280 lb. =5 bush.
Oatmeal (Scotland)	2 bolls	280 lb.
Gravel or Earth	Ton	20 cub. ft.
Hay	Old	18 cwt.
"	New	19 cwt. 32 lb.
Cartload	Scotland	15 to 25 cwt.
Faggots	Load	50 to 60.
Old English	5 Winchester qrs.	38·77789 bus.
Potatoes (Cheshire)	3 Hampers, each 84 lb.	252 lb. : 9 = ton.
Timber	Rough	40 cub. ft.
"	Squared	50 "
"	Inch planking	600 sup. ft.
Straw	36 trusses	11 cwt. 64 lb.
Tiles (pipe, 1 in.)		1,000.
Wheat	Imperial	5 quarters.
"	Market Load	5 bushels.
"	Winchester (Old English)	4·8472 qrs.
"	Sheffield, etc.	3 bushels.
"	Ulverston	4½ bus. (144 qts.).
"	Bedford, etc.	5 bushels.
Lugg (= pole : old)	16½ ft.	Coppice = 18½ ft.
Merk-land	1,600 sq. fathoms	1·32 ac.
Met (old)	Strike	1 bushel.
Metre	39·37079 in.	1·09363 yards
Mile	Imperial	1,760 "
"	Scottish	1,976·5226 "
"	Irish	2,240 "
"	Kilometre	1,093·6 "
"	Admiralty Knot	2,026·66 "
"	Geographical or Nautical Knot	2,027·55 "

TABLE 203—(*contd.*)

Molasses	Puncheon	10 to 12 cwt.
,,	Barrel (36 gals.)	5 to 6 cwt.
Mollie	Dutch Cucumbers	5 to 8 dozen.
Nail	Old	8 lb.
,,	Cloth	2·25 in.
Nitrate of Soda	Bag	2½ cwt.
,, ,,	Bushel	90 lb.
Noggin		1 gill.
Oats	Barrel	196 lb.
Oil	Gallon	9 lb.
Oil (Train)	,,	7½ lb.
Oil ,,	Ton	1,770 lb.
Oxgang, or Oxgate	Bovate	12 to 16 acres.
Pace	Military	2·5 ft.
,,	Geometrical	5 ft.
Palm	3·6 in. or	3 in.
Pad	Cucumbers	24 to 36.
Paper	Quire	24 sheets.
,,	Ream	20 quires.
Pint	Imperial	0·125 Imp. gall.
,,	Old English	0·12118 ,,
,,	Scots	0·3758 ,,
,,	Metric	·567 litre.
,,	Glasgow	0·5 Imp. gal.
Ploughgate	Hide (Scot.)	130 acres.
Plums	Carton	9 lb.
,,	¼ Box	20 ,,
Pork	Firkin	100 ,,
,,	Mess Barrel	200 ,,
,,	Army ,,	208 ,,
,,	Tierce (80 pieces)	320 ,,
Pot	Fruit	2 bushels.
,,	Peas	40 lb.
,,	Spinach	20 ,,
Potatoes	Uncleaned	120 lb. to cwt.
,,	Sack (London)	168 lb.
,,	Barrel	200 lb.
,,	Ton	45 bushels.
Pottle		2 quarts.
,,	Mushrooms	1 lb.
,,	Strawberries	½-gallon.
Pound	Old Apothecaries	12 oz. (5,760 grains).
,,	New ,,	16 oz. (7,000 grains).
,,	Avoirdupois	16 oz.
,,	Troy	12 ,,
,,	Old Edinburgh	22 ,,
,,	Old Glasgow (Trone)	22½ ,,
,,	Troyes of Dutch (Scot.)	17½ ,,
,,	Old Berwick and Dumbarton	23 ,,
,,	Selkirk	23½ ,,
,,	Ayrshire, Montrose, Brechin, Arbroath	24 ,,

TABLE 203—(*contd.*)

Pound	Kirkcudbright	26 oz.
,,	Kirriemuir	27 ,,
,,	Aberdeen	28 ,,
Punnet	Fruit = ½ to 4 lb.	1 lb.
Quintal (or Cental)		100 lb.
Rice	East Indian Bag	1½ cwt.
,,	American Cask	6 ,,
Rock Salt	Bushel	65 lb.
Rods	Building	36 sq. yd.
,,	Brickwork	272·25 sq. ft.
,,	Imperial	5·5 yds.
,,	Cheshire	8 ,,
,,	Irish Plantation	7 ,,
,,	Woodland	6 ,,
,,	" Fall " (Scot)	6·1766 yds.
Rundlet	Cask	11 gals.
Sack	Flour	280 lb.
,,	Corn	4 bushels.
,,	" Heaped " measure	3 ,,
,,	Coals	1 cwt.
Salt	Bushel	56 lb.
Score		20.
,,	Lettuce	22.
,,	Sheep (" Clad ")	21.
Seam	Glass	120 lb.
,,	Corn, Somerset	8 bushels.
,,	Wood	Horse-load
Selion (old)	A " Land "	Stetch.
Sieve	Vegetables	7 Imp. gals.
,,	Currants	20 quarts.
,,	Bushel, fruit	48 lb.
Soap	Firkin	64 ,,
,,	Chest	3¼ cwt.
Soft Soap	Firkin	64 lb.
,, ,,	Barrel	256 lb.
Span	10·9 in. or	9 in.
Square	Flooring and Thatching	100 sq. ft.
Stang	Pole	1 rod.
Steel	Faggot	120 lb.
Stere (cub. metre)	35·317 cub. ft.	1·308 cub. yds.
Stetch	" Land "	7 or 14 ft. ridge.
Stimpart	⅛ Winchester bushel	·97 gall.
Stone	Imperial	14 lb.
,,	Smithfield	8 ,,
,,	Old Hereford (Beef)	12 ,,
,,	Wool (Scots)	16 ,,
,,	Troyes or Dutch (Scot.)	17½ ,,
,,	Edinburgh Trone	22 ,,
,,	Glasgow	22½ ,,
,,	Ayrshire	24 ,,
,,	Galloway	28 ,,
,,	Glass (old)	5 ,,
,,	Wax	8 ,,
Straw	Truss	36 ,,
,,	Load (36 trusses)	11 cwt. 64 lb.

TABLE 203—(*contd.*)

Strike (old)		1 bushel.
Tar	Barrel	25 gall.
Tally	Vegetables	60.
Teaspoonful	⅛-ounce	1 drachm.
Threave	Corn sheaves	24.
Tiles, Pipe 1 in.	Load	1,000.
Ton	Imperial	2,240 lb.
,,	American	2,000 ,,
,,	Clay	17 cub. ft.
,,	Earth	18 ,,
,,	Sand	24 ,,
,,	Coal	10 sacks.
,,	Portland Cement	10 sacks = 6 casks.
,,	Shipping	42 cub. ft.
,,	Freight by measure	46 ,,
,,	Water	224 gals.
Trovet or Tofet (old)		½ bushel.
Treacle	Puncheon	10 to 12 cwt.
,,	Barrel (36 gallons)	5 to 6 ,,
Truss	New Hay	60 lb.
,,	Old ,,	56 ,,
,,	Straw	36 ,,
Ure	⅛ merk-land = 200 sq. fathoms	26·5 rods.
Virgate	" Yard "	15 to 40 acres.
Wey or Weigh	5 quarters	40 bushels.
Weigh	Cheviots	48 lb.
Wheat	Bushel (Standard at Mark Lane)	60 lb.
,,	Barrel	280 ,,
,,	Hobbet	168 ,,
,,	Windle	220 ,,
Wood	Cord	128 cub. ft.
,,	Stack	108 ,,
,,	Standard	165 ,,
,,	Fathom	216 ,,
,,	Seam	Horse-load.
,,	Square	100 sq. ft.
,,	One Hundred	120 deals.
Wool	Pack	240 lb.
,,	Legal Tod	28 ,,
,,	Stapler's Tod	29 or 30 lb.
,,	Stone (Scottish)	24 lb.
,,	German Bale	350 ,,
Yard of Land	14 acres = Standard	14, 15, 20, 24, 30, and 34 acres.
Yoke of Land	Day's work of 2 oxen.	¾ acre.

TABLE 204.
Useful Numbers

For converting	Multiply by	Converse
LENGTH		
Feet ... ... into links	1·5151	·66
Yards ... ... ,, ,,	4·545	·22
Feet ... ... ,, miles	·000189	5280
Yards ... ... ,, ,,	·00057	1760
Chains ... ... ,, ,,	·0125	80
Feet ... ... ,, metres	·3048	3·2809
Yards ... ... ,, ,,	·9144	1·0936
Chains ... ... ,, ,,	20·117	·049
Kilometres ... ,, ,,	·6214	1·6093
SQUARE		
Square ft. into sq. in. ...	144	·00694
Square yd. ,, sq. metres	·8361	1·196
Square yd. ,, sq. in. ...	1296	·000771
Square in. ,, acres ...	·000000159	6272640
Square ft. ,, ,, ...	·0000229	43560
Square yd. ,, ,, ...	·0002066	4840
Square yd. ,, sq. miles	·000000322	3097600
Square miles ,, acres ...	640	·001562
SOLID		
Cubic in. into cub. ft. ...	·000579	1728
Cubic ft. ,, ,, yards...	·03704	27
Cubic yd. ,, ,, metres	·7645	1·308
CAPACITY		
Cubic in. ... into bushels	·00045	2219·7
Cubic ft. ... ,, ,,	·778	1·285
Cubic in. ... ,, gallons	·003604	277·463
Cubic ft. ... ,, ,,	6·228	·1605
Bushels ... ,, ,,	8·00	·125
Gallons ... ,, litres ...	4·543	·220
Pints ... ... ,, ,, ...	·568	1·76
Litres ... ... ,, cu. ft.	·03532	28·33
WEIGHTS		
Lb. ... into cub. in. water	27·74	·036
Lb. ... ,, ,, ft. ,,	·016	62·5
Cub. ft. water ... into tons ...	·0278	35·9
Lb. ... ... ,, cwt. ...	·00893	112
Lb. ... ... ,, kilogs.	·454	2·2
Cwt. ... ... ,, ,,	50·8	·01968
Grammes ... ,, ounces	·0352	28·35

MISCELLANEOUS MEASURES.

Imperial Troy Weight

·003961 cub. in. of water ... ... = 1 grain (gr.).
3·20 grains ... ... = 1 carat.
24 grains ... ... = 1 pennyweight (dwt.).
20 pennyweights ... ... = 1 ounce (oz.).
12 ounces ... ... = 1 pound (lb.).
1 ounce ... ... = 480 grains.
1 pound ... ... = 5,760 grains.

The weight of a grain of wheat taken from the middle of the ear, well dried, is = "1 grain." The carat varies in weight: for ordinary business purposes it is taken at 150 to the ounce. The Troy pound is not used.

Imperial Avoirdupois Weight

27·34 grains (grs.) ... ... = 1 drachm (dr.).
16 drachms ... ... = 1 ounce (oz.).
16 ounces ... ... = 1 pound (lb.).
14 pounds ... ... = 1 stone (st.).
28 pounds ... ... = 1 quarter (qr.).
4 quarters ... ... = 1 hundredweight. (cwt.).
112 pounds ... ... = 1 cwt.
20 hundredweight ... ... = 1 ton.
1 ounce ... ... = 437½ grains.
1 pound ... ... = 7,000 grains.

Imperial Measure of Capacity

5 ounces of water ... ... = 1 gill.
4 gills ... ... = 1 pint (pt.).
2 pints ... ... = 1 quart (qt.).
4 quarts ... ... = 1 gallon (gal.).
2 gallons ... ... = 1 peck (pk.).
4 pecks ... ... = 1 bushel (bus.).
8 bushels ... ... = 1 quarter (qr.).
4 quarters ... ... = 1 chaldron.
10 quarters ... ... = 1 last.

These measures are used up to the gallon for liquids, and from the peck upwards for dry goods.

Imperial Wine Measure

(For all Wines and Liquids)

4 gills ... ... = 1 pint (pt.).
2 pints ... ... = 1 quart (qt.).
4 quarts ... ... = 1 gallon (gal.).
10 gallons ... ... = 1 anker (ank.).
18 gallons ... ... = 1 runlet (run.).
31½ gallons ... ... = 1 barrel (bar.).
42 gallons ... ... = 1 tierce (tier.).
2 tierces ... ... = 1 puncheon (pun.).
63 gallons ... ... = 1 hogshead (hhd.).
2 hogsheads ... ... = 1 pipe (pipe).

2 pipes ... ... = 1 tun (tun).

Wine bottle = 1/6 gal. = 2/3 fl. oz.

IMPERIAL ALE AND BEER MEASURE
(For Malt Liquors and Water)

2 pints ... ... = 1 quart (qt.).
4 quarts ... ... = 1 gallon (gal.).
8 gallons ... ... = 1 firkin (fir.) (ale).
9 gallons ... ... = 1 firkin (fir.) (beer).
18 gallons ... ... = 1 kilderkin (kil.).
36 gallons ... ... = 1 barrel (bar.).
1½ barrels (54 gals.) ... ... = 1 hogshead (hhd.).
72 gallons ... ... = 1 puncheon (pun.).
2 hogsheads ... ... = 1 butt (butt).
2 butts ... ... = 1 tun (tun.).

IMPERIAL CORN MEASURE

2 quarts ... ... = 1 pottle (pot.).
2 pottles ... ... = 1 gallon (gal.).
2 gallons ... ... = 1 peck (pk.).
4 pecks ... ... = 1 bushel (bus.).
2 bushels ... ... = 1 strike (str.).
4 bushels ... ... = 1 coomb (coomb).
4 bushels ... ... = 1 sack.
2 coombs or 8 bushels ... ... = 1 quarter (qr.).
4 quarters ... ... = 1 chaldron.
5 quarters ... ... = 1 load (load).
2 loads or 10 qrs. ... ... = 1 last (last).

The gallon has the same capacity in all Imperial measures and was fixed by the Board of Trade in 1890 at 277·463 cubi inches, or = 10 lbs. of distilled water at 62° F. and baromete at 30 in. The old capacity was 277·274 cubic inches. Th United States gallon is 231 cubic inches or 8·34 lb. of water The bushel is 1·28 cubic feet: 19½ in. diameter, and 8¼ in deep. The United States bushel is 2,150·4 cubic inches = ·9688 of an Imperial bushel. Corn of all kinds is now legall sold and prices quoted at per cwt. of 112 lb.

IMPERIAL LINEAL MEASURE

72 points ... ... = 1 inch (in.).
12 lines ... ... = 1 inch (in.).
12 inches ... ... = 1 foot (ft.).
3 feet ... ... = 1 yard (yd.).
6 feet ... ... = 1 fathom (fth.).
5½ yards ... ... = 1 rod, perch, or pole (po.).
40 poles ... ... = 1 furlong (fur.).
8 furlongs ... ... = 1 mile (m.).
3 miles ... ... = 1 league (lea.).
69 1/9 miles ... ... = 1 degree (deg. or °

The chain used for measuring land is 4 poles, or 22 yd. ong, and consists of 100 links, each link being 22 100 yd., or 27·9 in. long. 10,000 square links = a square chain; 25.000 quare links = square rood; 100,000 square links, or 10 square hains = 1 acre. A furlong multiplied by a chain = 1 acre.

Gunter's Chain Measure

7·92 inches ... ... = 1 link (lk.).
100 links ... ... = 1 chain (ch.).
80 chains ... ... = 1 mile (m.).

Imperial Square Measure

144 square inches ... ... = 1 square foot (sq. ft.).
9 square feet ... ... = 1 square yard (sq. yd.).
30¼ square yards ... ... = 1 square pole (sq. po.).
40 square poles ... ... = 1 rood (ro.).
4 roods ... ... = 1 acre (ac.).
640 acres ... ... = 1 square mile (sq. m.).
6,272,640 square inches ... ... = 1 acre.
43,560 square feet ... ... = 1 acre.
4,840 square yards ... ... = 1 acre.
160 square rods ... ... = 1 acre.
10 square chains ... ... = 1 acre.

Solid Measure

1,728 cubic inches ... ... = 1 cubic foot (cub. ft.)
27 cubic feet ... ... = 1 cubic yard (cub. yd.).
A barrel bulk ... ... = 5 cubic feet.
A ton of timber, shipping ... ... = 42 cubic feet.
A ton of freight ... ... = 40 cubic feet.

Fluid Measure

60 minims (m) ... ... = 1 fluid drachm (f ʒ).
8 drachms ... ... = 1 ounce (f ℥)
20 ounces ... ... = 1 pint (O).
8 pints ... ... = 1 gallon (C or gal.).

Symbols used in Prescriptions

a.a. ... ... = of each.
fl ... ... = fluid.
ft. ... ... = make.
gtt. ... ... = drop.
j or i ... ... = one.
ij ... ... = two.
iij, etc. ... ... = three, etc.
M. ... ... = mix.
P.r.n. ... ... = as occasion requires.
Q.S.... ... ... = sufficient quantity.
R ... ... = take off.
s.s. ... ... = one-half.

And also the symbols used in Fluid Measure.

Cheese and Butter

8 lb. cheese ... ... = 1 clove or ½-stone.
32 cloves = 256 lb. ... ... = 1 Suffolk wey.
42 cloves = 336 lb. ... ... = 1 Essex wey.
56 lb. butter ... ... = 1 firkin.
84 lb. butter ... ... = 1 tub.
224 lb. butter ... ... = 1 barrel.

Hay and Straw Weight

36 lb. Imp. of straw ... ... = 1 truss.
56 lb. of old hay ... ... = 1 truss.
60 lb. of new hay ... ... = 1 truss.
36 trusses ... ... = 1 load.
A load of straw... ... ... = 11 cwt. 64 lb.
A load of old hay ... ... = 18 cwt.
A load of new hay ... ... = 19 cwt. 32 lb.

Hay sold between 1st June and 31st August is reckoned new hay. Hay sold between 31st August and the succeeding 1s June is reckoned old.

Wool Weight

7 lb. Avoirdupois ... ... = 1 clove.
14 lb. or 2 cloves ... ... = 1 stone.
28 lb. or 2 stones ... ... = 1 tod.
182 lb. or 6½ tods ... ... = 1 wey.
364 lb. or 2 weys ... ... = 1 sack.
4,368 lb. or 12 sacks ... ... = 1 last.

20 lb. = 1 score, and 240 lb. or 12 scores = 1 pack. In practice, wool buyers frequently reckon 29 or 30 lb. to the tod.

Timber Measure

100 superficial feet of planking ... ... = 1 square.
120 deals ... ... = 1 hundred.
108 cubic feet ... ... = 1 stack.
128 ,, ,, ... = 1 cord.
50 ,, ,, squared timber ... ... = 1 load.
40 ,, ,, rough timber ... ... = 1 ,,
600 superficial feet 1 in. planking ... ... = 1 ,,
720 superficial feet 3 in. × 11 in. = 165 cu. ft. = 1 standard.

Seasons

Spring commences 21st March.
Summer ,, (longest day) 21st June.
Autumn ,, 23rd September.
Winter ,, (shortest day) 21st December.

Thirty days hath *September*,
April, *June*, and *November* ;
February hath twenty-eight alone,
All the rest have thirty-one ;
But Leap Year coming once in four,
February then has one day more.

ANGULAR MEASURE

60 seconds (″) ... ... = 1 minute (′).
60 minutes ... ... = 1 degree (° or deg.).
30 degrees ... ... = 1 sign (s.).
45 ,, ... = 1 octant
60 ,, ... = 1 sextant.
90 ,, ... = 1 right angle or quadrant.
180 ,, ... = 1 semicircle.
360 ,, (12 signs) ... ... = 1 circumference.
3·1416 diameters nearly ... ... = 1 circumference.

DOMESTIC MEASURES

1 teaspoonful = 1 drachm = ⅛-ounce.
1 dessertspoonful = 2 drachms = ¼ ,,
1 tablespoonful = 4 ,, = ½ ,,
1 wineglassful = 2½ ounces = ½-gill.
1 teacupful = 5 ,, = 1 ,,
1 tumblerful = 10 ,, = 2 gills.

A halfpenny is 1 in. diameter, and 3 pennies = 1 oz. in weight.

Metric System

LONG MEASURE

	Metre	Inches	Feet	Yards	Miles
Millimetre ..	·001	·03937	·00328	·00109	—
Centimetre ..	·01	·3937	·0328	·0109	—
Decimetre ..	·1	3·937	·328	·1093	·00006
METRE ..	1	39·37079	3·2809	1·0936	·00062
Decametre ...	10	—	32·809	10·9363	·00621
Hectometre ...	100	—	328·09	109·363	·06213
Kilometre ..	1,000	—	3,280·9	1,093·63	·62138
Myriametre ...	10,000	—	—	—	6·21382

SQUARE MEASURE

	Square Metres	Square Inches	Square Feet	Square Yards	Acres
Milliare ...	·1	155	1·076	·119	—
Centiare ...	1	1,550	10·764	1·19	·00024
Deciare ...	10	15,501	107·64	11·96	·00247
ARE	100	—	1,076·4	119·6	·02471
Decare ...	1,000	—	—	1,196	·24711
Hectare ...	10,000	—	—	11,960	2·47110

SOLID MEASURE

	Cubic Metres	Cubic Inches	Cubic Feet	Cubic Yards
Millistere	·001	61·028	—	—
Centistere	·01	610·28	·353	—
Decistere	·1	6,102·8	3·531	·13
STERE, or cubic metre ...	1	61,028	35·317	1·308
Decastere	10	—	—	13·08
Hectostere	100	—	—	130·802

A *cubic centimetre* is ·061028 of a cubic inch.

WEIGHTS

	Grammes	Avoir. oz.	Avoir. lbs.	Cwts.	Tons	Grains Avoir.
Milligramme	·001	—	—	—	—	·105
Centigramme	·01	—	—	—	—	·154
Decigramme...	·1	—	—	—	—	1·543
GRAMME ...	1	·035	·0022	—	—	15·432
Decagramme	10	·352	·022	—	—	—
Hectogramme	100	3·527	·2204	—	—	—
Kilogramme	1,000	35·274	2·2046	·019	·00098	—
Myriagramme	10,000	—	22·046	·196	·00984	—
Quintal ...	100,000	—	220·462	1·968	·0984	—
Millier or Bar	1,000,000	—	2204·62	19·684	·9842	—

DRY AND FLUID MEASURE

	Litres	Inches	Feet	Gallons	Bushels
Millilitre ...	·001	·061	—	·00022	—
Centilitre ...	·01	·61	—	·0022	—
Decilitre ...	·	6·1	—	·022	0027
LITRE	1	61·02	·0353	·22	·0275
Decalitre ...	10	610·28	·353	2·2	275
Hectolitre ...	100	—	3·53	22	2·751
Kilolitre ...	1,000	—	35·317	220·09	27·512
Myrialitre ...	10,000	—	353·17	2,200·9	275·121

1 pint ... ... = ·56793 litres.
1 quart ... ... = 1·13587 „
1 gallon ... ... = 4·54346 „
1 peck ... ... = 9·08692 „
1 bushel ... ... = 36·34768 „

The Metric System is based on the *metre* (39·3709 in.), which is the ten-millionth part of the quadrant of a terrestrial meridian. The *litre* is the cube of the tenth part of a metre ; the weight of a litre of distilled water at its greatest density is a *kilogramme*, and one-thousandth of this is a *gramme* (= 15·4 grains avoir.) ; the *are* is 100 square metres and the *stere* one cubic metre.

Table 205.
Comparative Scales of Thermometers

Centigrade or Celsius	Fahrenheit.	Reaumur.	Centigrade or Celsius	Fahrenheit.	Reaumur.
100	212·0	80·0	50	122·0	40·0
98	208·4	78·4	48	118·4	38·4
96	204·8	76·8	46	114·8	36·8
94	201·2	75·2	44	111·2	35·2
92	197·6	73·6	42	107·6	33·6
90	194·0	72·0	40	104·0	32·0
88	190·4	70·4	38	100·4	30·4
86	186·8	68·8	36	96·8	28·8
84	183·2	67·2	34	93·2	27·2
82	179·6	65·6	32	89·6	25·6
80	176·0	64·0	30	86·0	24·0
78	172·4	62·4	28	82·4	22·4
76	168·8	60·8	26	78·8	20·8
74	165·2	59·2	24	75·2	19·2
72	161·6	57·6	22	71·6	17·6
70	158·0	56·0	20	68·0	16·0
68	154·4	54·4	18	64·4	14·4
66	150·8	52·8	16	60·8	12·8
64	147·2	51·2	14	57·2	11·2
62	143·6	49·6	12	53·6	9·6
60	140·0	48·0	10	50·0	8·0
58	136·4	46·4	8	46·4	6·4
56	132·8	44·8	6	42·8	4·8
54	129·2	43·2	4	39·2	3·2
52	125·6	41·6	2	35·6	1·6
50	122·0	40·0	0	32·0	0·0

Thermometers should be tested if wanted for accurate work, as the cheap forms on sale are often very inaccurate.

Formulae for Converting Degrees

$$F = \frac{9\,C}{5} + 32\ ;\ F = \frac{9\,R}{4} + 32\ ;\ F = C + R + 32$$

$$C = \frac{5\,(F - 32)}{9}\ ;\ R = 4\,\frac{(F - 32)}{9}$$

INTERNAL COMBUSTION ENGINE DATA

To find the indicated horse-power of engine :—

$$I\,H\,P = \frac{P\,L\,A\,N}{33{,}000}$$

Where P = Mean effective pressure in lb. per sq. in. on the piston.
L = Length of stroke in ft.
A = Area of piston in sq. in.
N = Number of working strokes per minute.

Fuel Consumption

Type of engine	Pints per brake h.p./hour
Diesel	·45
Petrol	·75
Vaporising Oil	·80

Tractors

Drawbar horse-power

$$= \frac{\text{Drawbar pull in lb.} \times \text{speed in m.p.h.}}{375}$$

$$\text{Speed in m.p.h.} = \frac{\text{Distance in chains} \times 45}{\text{Time in seconds}}$$

Tractor speeds in the field vary from ½-m.p.h. for certain row crop work to 5 m.p.h. for transport. A usual ploughing speed is 2½–3 m.p.h. On average land 5 draw-bar horse-power is required to draw a single furrow plough at 3 m.p.h. This same power, i.e., 5 draw-bar horse-power, would draw 2 ft. 6 in. width of cultivator; 4 ft. width of drill; 4 ft. width of binder.

Driving Wheel Slip—To estimate the slip of driving wheels a mark should be painted on the wall of one of the tyres or on the metal rim to facilitate counting the number of revolutions of the wheel. With the implement in work the distance the tractor travels while the driving wheel makes ten revolutions is marked on the ground by pegs, and then measured. Next, the implement is unhitched (or is lifted out of work if it is a unit-principle outfit) and the tractor is run free in the same gear as before, and the distance of travel for ten revolutions of the driving wheel is measured again. The difference between these two distances, divided by the distance travelled without a load, and multiplied by 100, gives roughly the percentage of slip. If the percentage is more than 18, something ought to be done to reduce it or fuel is wasted.

One way of reducing the slip is to reduce the load of work but often wheel slip occurs before the work load is great enough to place a full demand on the engine. In such cases, if the grip of the driving wheels is improved the tractor can deal with a heavier load more economically. Improving wheel grip can sometimes relieve the engine by reducing the loss of power due to the rolling resistance of the wheel passing over the ground. When tyres are slipping to the point of digging in, the rolling resistance often becomes so high the engine stalls. The grip of the driving wheels can be improved by adding ballast or by fitting strakes.

Spade-lugged steel wheels rarely slip seriously without digging in, and a calculation is rarely necessary. Moreover, an inspection of the impressions left in the soil by the lugs of the wheels when the tractor is pulling its load is sufficient guide to whether excessive slip is present. When the impressions retain about the same shape as the lugs themselves the wheel is gripping satisfactorily ; if the imprint is much enlarged there is too much slip. The grip of steel wheels can also sometimes be improved by ballast to cause deeper penetration of the lugs into the soil. A frequent cause of slip is worn spade lugs, which not only lose length for penetration but become rounded instead of wedge shaped.

When the driving wheels are gripping well the driver should avoid taking undue advantage by increasing the load to a point where the engine is overworked. With a little practice and thought one can judge this by listening to the rhythm of the engine ; when the speed of the engine seems to have been brought down and the exhaust note indicates that the engine is labouring the load should be reduced or a lower gear engaged.

The Tractor on Light Work—Much of the work done by tractors in summer is a light load for the engine. Haymaking and harvesting do not demand such continuous high power output as ploughing or heavy cultivation in winter and spring. When tractors are used in hay and corn fields they may move only a few yards at a time and the draught may be no greater than a horse could manage. During this very light work, certain precautions must be taken to avoid expensive tractor deterioration.

When the tractor is burning vaporising oil idling may well dilute the lubricating oil and make it so thin it cannot protect the moving surfaces in the engine from wear, an effect not immediately noticeable. Another trouble during idling which is apparent to the ear is the oiling-up of one or more sparking plugs. The uneven beat of the engine is soon detected ; but it does not follow that the driver is always ready to clean the plug immediately. A four cylinder engine running on three cylinders, although it may have a distressing exhaust note, still has plenty of power to pull wagons, and the temptation is to leave plug cleaning until later. Very often, too, the plug oils up again a few minutes after cleaning if the tractor is put back on to light work.

When an engine runs with one cylinder out of commission great harm is done to the engine, particularly if the fuel is vaporising oil. The uneven running causes excessive wear in the bearings and the walls of the cylinder in which no power stroke is occurring has the lubricating oil washed away by the unexploded intakes of vaporising oil.

Oiling-up of plugs may be due to worn piston rings or worn cylinder walls, and may therefore be an indication that the engine needs a major overhaul ; but it does happen with engines that are otherwise in good order. If the engine runs well except when on light work, then a satisfactory remedy for the oiling-up may lie in keeping a set of special plugs to be used on occasions when the tractor is to have a spell of light jobs.

Sparking plugs of several types are available to suit varying conditions. Some are designed to keep hot in a cool engine, others to keep cool in a hot engine. The manufacturer of the tractor fits a plug to suit the particular design of engine and is anxious when plugs are replaced the new ones cover the same heat range. This selection of plug type is usually made on the assumption the engine will be working hard, as for example when ploughing.

The manufacturer may specify a " cold " plug in order to prevent rapid burning away of the points, and to do away with the tendency to pre-ignition caused by hot metal in and around the plug. Sometimes plugs which give perfectly satisfactory results when the engine is working hard and keeping hot have a tendency to oil-up when the machine is idling or running light. Therefore, in the case of a tractor, prone to oil-up when running light, it may be worth while to have a spare set of plugs of the hot type to fit into the tractor temporarily while it is on small, intermittent jobs.

The idling period between bouts of work may be long compared with the working time and the operator must make up his mind whether it is better to leave the engine running or to stop and start again. This decision is influenced by the ease or difficulty of re-starting the tractor. An engine with an electric starter is more likely to be stopped, but a vaporising oil engine which has to be started by hand is quite likely to be left running for periods long enough to waste fuel and perhaps damage the engine by the dilution of the lubricating oil.

If the tractor has an electric starter the battery will run down if the starter is used frequently with only short periods of work for recharging. Discharge of the battery is very rapid if the engine is in poor condition and the starting motor has to be engaged for a long time before the engine responds. Therefore, it pays to give attention to both ignition and carburettor.

When running on vaporising oil, should the engine be stopped long enough to get really cool, the vaporising oil must be turned off and the float chamber of the carburettor emptied of vaporising oil to ensure when starting again the float chamber contains only petrol with no mixture of vaporising oil.

Heavy ploughing and cultivating keep the engine working so hard that even on a very cold day its temperature is high enough to deal efficiently with the vaporisation of the fuel, but an engine which is just ticking over while the tractor is idle may stay cool enough for vaporising oil to remain wet in the cylinder and seep down past the pistons to dilute the lubricating oil in the sump.

Unless the tractor is fitted with thermostatic control, the radiator blinds should be used on light work to blank off part of the cooling surface. If better means are not available a sack or an old coat can be used to cover up the radiator. These precautions are usually needed in summer as well as winter.

Some light summer jobs are performed in conditions where the air is particularly heavily laden with dust or chaff. Tractors pulling trailers serving combine harvesters often draw into the air cleaner large quantities of dried material of a very abrasive kind. Air cleaners should be given more frequent attention, therefore, under these conditions than when, for example, the tractor is ploughing a field in winter.

Care given to details of maintenance in this way especially in nursing the engine when it is working light, minimises deterioration of the tractor and ensures low fuel consumption.

Electricity

Watts = volts × amps.
1,000 watts = 1 kilowatt.
1 kilowatt per hour = 1 unit.
1 unit is equivalent to 3,400 B.Th.U's. (British Thermal Units)
1 B.Th.U. will raise temperature of 1 lb. of water through 1° F.
746 watts = 1 h.p.

WATER POWER

Theoretical Horse-power of Water

Q = quantity of water in cubic feet per minute.
H = head of water above tail race in feet.
P = theoretical horse-power.
62·5 = weight of cubic foot of water in lbs.

$$P = \frac{Q \times 62{\cdot}5 \times H}{33{,}000}$$
$$= {\cdot}001892\ Q\ H$$

Water Data

1 cubic foot of water = 62·425 lb. = ·557 cwt. = ·028 ton.
1 cubic inch ... = 0·3612 lb.
1 gallon ... ... = 10 lb. = ·16 cu. ft.
1 cubic foot ... = 6·24 gals. = 6¼ gals. (say).
1 cwt. ... ... = 1·8 cu. ft. = 11·2 gals.
1 ton ... ... = 35·9 cu. ft. = 224 gals.
1 cu. ft. of sea water = 64·11 lb. = 1·027 weight of fresh water.
1 in. per acre ... = 101·28 tons = 22,622·52 gallons.

Water occupies least space at 4° C. = 39° F.

P = pressure in lb. per square inch.
= ·4335 lb. per foot in depth.
H = head of water in feet.
V = theoretical velocity in feet per second.
$P = H \times {\cdot}4335$; $H = P \times 2{\cdot}307$.
$V = 8{\cdot}025 \div H$; $H \times 62{\cdot}5$ = pressure in lb. per square foot.

The effective horse-powers of the various water motors are :—

Theoretical power	1·00
Undershot wheels	·35
Poncelet's undershot wheel	·60
Low-breast wheel	·55
High-breast wheel	·60
Overshot wheel	·68
Turbine	·80
Hydraulic ram raising water	·60

Gauging Water

H = height of surface of water above sill in feet.
B = width of sill in feet.
Q = cubic feet discharged over the sill per second.

$$Q = 3{\cdot}2\ BH\ \sqrt{H}$$

3·2 is result of experiment, taking the contraction of flow nto account.

In gauging, the water must all be made to pass through a rectangular aperture with a thin waste-board or sill. The height must be measured from the top of the sill to the level of the surface where it is not affected by the overfall. The sill must have a free overfall. For very accurate results a triangular notch or aperture is preferred, in which case $Q = 2{\cdot}64\ H^2 \sqrt{H}$.

Overshot Water Wheel---To find the H.P. :—

H = fall between point where laid on and point where water leaves the wheel.

Q = quantity of water in cubic feet per minute laid on wheel.

P = useful effect in horse-power.

$$\text{Then } P = \frac{Q \times H \times 62{\cdot}5 \times {\cdot}68}{33{,}000}$$
$$= {\cdot}001285\ Q\ H.$$

The point at which the water ought to be laid upon an overshot wheel is 52° 45′ below its vertex, or 37° 15′ above the centre.

Undershot Water Wheel

$$P = \frac{Q \times H \times 62{\cdot}5 \times {\cdot}35}{33{,}000}$$
$$= {\cdot}000662\ Q\ H$$

Poncelet's Undershot Water Wheel

$$P = \frac{Q \times H \times 62{\cdot}5 \times {\cdot}60}{33{,}000}$$
$$= {\cdot}00113\ Q\ H.$$

Breast Water Wheel

P = ·00104 Q H for low-breast wheels ;
= ·00113 Q H for high-breast wheels.

Buckets

Distance apart in high-breast or overshot	12 in.
,, ,, low-breast	18 ,,
Openings of buckets in high-breast	6 to 8 ,,
,, ,, low-breast	9 to 12 ,,

In the Poncelet undershot wheel the buckets have a curve, up and back down which the water glides easily, so that there is no shock or jar, and the water thus gives up the whole of its kinetic energy. It is the best form of wheel for small heads of water.

Turbines

$$P = \frac{Q \times H \times 62{\cdot}5 \times {\cdot}70}{33{,}000}$$
$$= {\cdot}00132\ Q\ H.$$

Turbines are best used where there is a large head giving high pressure of water.

TABLE 206
DESCRIPTIONS OF VELOCITY AND FORCE OF THE WIND

Miles per Hour	Feet per Second	Force in lb. per Sq. ft.	Description.
1	1·47	·005	Hardly perceptible.
2	2·93	·020	Just perceptible.
3	4·4	·044	
4	5·87	·079	Gentle breeze.
5	7·33	0·123	
10	14·67	0·492	Pleasant breeze.
15	22·0	1·107	
20	29·3	1·968	Brisk gale.
25	36·6	3·075	
30	44·0	4·428	High wind.
35	51·3	6·027	
40	58·6	7·872	Very high wind.
45	66·0	9·963	
50	73·3	12·300	Storm.
60	88·0	17·712	Great storm.
70	102·7	24·108	
80	117·3	31·488	Hurricane.
100	146·6	49·200	Hurricane that tears up trees, carries away buildings, etc.

The theoretical value of wind velocity (its capacity for doing work through a vaned screw) increases in the ratio of the squares of the different velocities; thus a 20-mile wind is four times more effective than one of 10 miles.

Hydraulic Ram—Where there is a small head of water a ram will raise a supply most economically any height up to 1,000 ft. Usually one-seventh part of the water flowing in inlet pipe can be raised to four times the height of head; one-fourteenth eight times; one twenty-eighth 16 times, and so on. If h the height to be raised, H the head of water, Q the total quantity of water, and q the amount raised, then the supply yielded is $q = \frac{0{\cdot}5\ Q\ H}{h}$

It is desirable to have a head of at least 6 ft., but down to 18 in. will work proportionately well. There are also compound rams to be had, which will work with dirty water from a stream and raise pure water from a well.

Gravitational Delivery of Water in Pipes

G = Number of gallons delivered per hour.
L = Length of pipe in yards.
H = Head of water in feet.
D = Diameter of pipe in inches.

$$G = \frac{(15\ D)^2\ H}{L}$$

HORSE AND ANIMAL POWER

(Working eight hours per day)

Watt's standard horse-power = raising 33,000 lb. 1 ft. high in 1 minute = 33,000 units of work., i.e., foot-pounds.

	Units.
Average of actual farm-horses walking 2½ miles per hour ... ... =	22,000
Large horse in cart, walking 2½ miles per hour ... =	26,000
Horse in plough, walking 1½ miles per hour ... ... =	22,000
Light horse (1,200 lb) in general work ... ... =	20,000
Pony (1,000 lb.) in general work ... ... =	17,000
Man walking up incline... ... ... =	4,230
„ rowing ... ... =	4,000
„ standard ... ... =	3,300
„ pushing or pulling weight horizontally ... ... =	3,130
„ on tread-wheel ... ... =	3,100
„ turning winch ... ... =	2,600
„ pumping ... ... =	2,390
„ raising weights by pulley ... ... =	1,560
„ „ „ hand ... ... =	1,480
„ carrying weight up incline ... ... =	1,130
„ wheeling loaded barrow up incline ... ... =	520
„ lifting earth with spade 5¼ ft. ... ... =	470

Tractive Force of Horses

Rate in miles per hour	1½	2	2½	3	3½	4	4½	5
Tractive force exerted, in lb.	203	176	150	125	104	83	62	4

A horse produces his greatest mechanical effect in drawing a load at 2½ miles per hour with a tractive force of 150 lb.

Draught of Horses—At 8 hours per day, 2½ miles per hour, and tractive force of 150 lb. :—

On level hard road	3 tons.
On inferior or hilly road	1 ton.
On rails	16 tons.
On a canal	60 to 90 tons.
Carrying on his back	300 lb.
Lifting over a pulley	110 lb.

The average draught power of a horse is from ⅛th to $\frac{1}{10}$th of his weight for a steady day's work, but he can pull up to half this weight for short periods. Ploughing at 1½ miles per hour, the usual draught is 170 to 280 lb. per horse, and size of furrow slice (width and depth) is adapted to suit this ; heavy Shires will pull up to 300 lb. however. The pressure of horses' feet on soil is about 14 lb. per square inch.

One actual horse-power will perform each of the following jobs per hour :—

Grind about 2 bushels corn.
Kibble about 7 bushels corn.
Bruise about 12 bushels corn.
Break about 10 cwt. cake.
Pulp about 20 cwt. roots.

Threshing Machine Data

Drum—Revs. per min.	1,200	Fan—Revs. per min. ...	700
Shakers—Revs. per min.	180	Elevator—Revs. per min.	100
Riddles—Revs. per min.	180	Screen—Revs. per min. ...	25
Height	10 ft.	Width of platform ...	13 ft.
Width—Wheel to wheel	8½ ft.	Length	10 ft.
Length	17 ft.		

Distance between drum and concave at bottom ... ⅜ in.
" " " at middle ... ⅝ "
" " " at top ... 1½ "

TABLE 207.

Width of drum ... ... in.	60	54	48
Horse-power of engine required ...	8–10	6–8	4–6
Wheat thrashed per hour, bushels ...	60–80	50–70	40–60
Weight of machine ... ... cwt.	92	85	80

One-third to one-half more bushels of oats or barley than of wheat thrashed in a given time.

Weight of trusses from straw trusser, 24 lb.

To get a good sample of grain, the speed of the drum and the spacing between the concave and the beaters must be adjusted to suit the particular crop being threshed. The machine must be set dead level and the corn fed evenly to the drum.

Securing a good sample of grain is only part of the object of threshing. To deal efficiently with the straw, and to dispose of the cavings and the weed seeds, the threshing box must be served by carefully chosen and correctly adjusted accessories.

The wheels or axles of the thresher must be jacked until a spirit level shows the box to be exactly horizontal or the bearings of the drum will wear unduly and the shakers and riddles will not function properly.

Before the main driving belt is put on and the tractor or steam engine lined up, the small belts should be fitted, some of which have to be put on crossed. Care must be taken to see the main pulley of the thresher is accurately in line with the pulley of the engine or tractor driving the thresher.

For wheat and barley an average setting for the distance between the inner edge of the bars of the concave and the outer surface of the drum beaters is three-quarters of an inch at the top, half an inch at the centre, and a quarter of an inch at the bottom. These distances must be made smaller if the grain is small. They must be reduced also if the corn is threshed soon after harvest with little time to dry out in the stack.

The final adjustment of the setting must be made by trial and error. The distance should be set wide when the machine is first put to work, and then gradually reduced until no grain appears at the straw outlet.

The straw shakers, the sieves, the elevators and all the other moving parts of the thresher are driven from the drum shaft. If the subsidiary belts are correctly adjusted these parts will work at the right speed when the drum is rotating at the right speed. The speed can be varied within the range of the governor control of the driving engine. There are some general rules for selecting the speed, such as fast for damp grain, but, as with the setting of the concave, trial and error methods must be used, and the condition of the product at the various delivery chutes is the best guide.

Even feeding of the sheaves into the threshing machine is essential ; the drum must be kept hard at work, but it must not be choked. A self-feeder helps to this end and also saves labour, the usual type being in the form of a conveyor belt.

The products from the thresher should be dealt with quickly to prevent congestion, the full sacks being taken away and put under cover. If small weed seeds are collected to be sold for bird seed care must be taken that all the seeds are gathered and none left to blow about the farm.

The greatest problem is to deal with the straw. If it is to be stacked again near where the ricks of corn have stood, a mechanical elevator, driven either from one of the secondary pulleys of the thresher or from a small stationary engine, is ikely to be used. The elevator must be kept in good order ; an inefficient elevator creates a " bottle neck " soon bringing the whole operation to a standstill. Before work begins bent hooks in the elevator should be hammered back to the correct angle and any doubtful links in the conveyor chain replaced.

If the straw is to be stored at the homestead it is best bundled, straight from the thresher, by a simple string-tying trusser. If for sale it is better to bale using wire. The ram baler for this work can be driven from a pulley of the thresher if the thresher engine has enough surplus power, but this method must not be used with a light threshing machine. The secondary pulley shafts and bearings on light threshers are not sufficiently strong to stand the driving of a heavy baler and a separate engine or at any rate a separate drive, must be used.

Balers are strong, heavy machines, and their maintenance lies chiefly in lubrication.

Oat straw is often chaffed to be used in a feeding mixture, and here, again, it is generally desirable to deal with the straw straight from the thresher, and carry away the chaff in bags.

The knives of chaff cutters must be kept sharpened and properly set if the machine is to cut for hours at a stretch without attention. To adjust the pitch of the knives, the set screws for each knife should be turned, a little at a time, until the edge of the knife is in such a position that it touches the shear plate along the whole length of the knife.

Usually a power driven chaff-cutter has a three-speed gear for changing the ratio between the speed of the feed of the straw and the speed of the rotation of the knives. Each speed gives a different length of cut and machine produces fine, medium or coarse grade of chaff. The change speed pinions and the bevel gears driving the speed rollers and the conveyors must be kept well lubricated.

Overhauling the threshing machine itself is a job to be undertaken at a time of the year when it will not get hurried.

Before adjusting any of the bearings, screw up the nuts of the bolts that hold the frame of the threshing box together to ensure when the whole structure is rigid any adjustments made to the bearings will not be upset when the machine is moved.

If the frame is made of oak the nuts and bolts may be corroded from the tannic acid from the wood. If this is so, penetrating oil should be used. It is not likely this trouble will occur if the frame is made of pitch pine, for resin has the effect of preserving the nuts and bolts.

Before beginning any adjustments inside the box the main driving belt should be taken off.

Most of the bearings are simple and of brass and these can be adjusted for wear by filing the flats, or, if necessary, by scraping the bearing surfaces to bring back their circular form.

The ring oil bearings should be cleaned out by removing the top plug and bottom tap to drain away the old oil. The bottom tap can then be closed and fresh oil poured through the top plug hole until the level of the reservoir reaches the mark on the glass eyelet.

On some threshers the drum bearings and some of the other high speed bearings are ball bearings which have grease cups on the bearings. These cups must be charged, and screwed down sufficiently to force the grease into the bearing.

The chaff blower bearers, which are usually wick oiled, can be replaced with new ones if they are at all stiff and dirty.

Threshing Grasses and Linseed GRASS SEED All grass seed crops, except timothy, may be threshed cleanly by an ordinary corn thresher to which a few adjustments and additions have been made. To reduce the escape of heads through the grating, either a metal shield must be fitted at the back of the concave in its upper third, or the back of the concave must be packed with straw. The final setting of the concave relative to the beaters of the drum can be found only by trial and error, but a good setting to begin with is one which will give a clearance of ⅜-in. from the drum beaters at the top, ½-in. in the centre, and ¾-in. at the bottom. A rule to temember in setting the concave, for grass as for any other crop, is that it should be no nearer than is found to be necessary to remove the seed.

For ryegrass, the drum speed should be about 1,100 r.p.m. whilst for cocksfoot, a speed of about 1,200 r.p.m. may be needed. for the best results.

To keep back as much of the cavings as possible, the caving riddle should be blanked out for two or three sections at the end near the drum.

Losses of seed are usually prevented by reducing the blast. Partly closing the shutters of the first blower is normally sufficient but on some machines it may be necessary to fit a sheet of tinplate or cardboard over the air inlet. Another way of reducing the wind is to cut down the fan speed of both the first and second dressers by fitting larger pulleys on to the fan spindles. A pulley of 14 in. diameter instead of 11 in. on the first dresser, and a 6 in. pulley instead of the 4 in. on the second dresser gives about the right reduction in speed.

The rotary screen should be closed, so the best seed falls through at the end where the tail corn would fall. Unthreshed material falls through the best corn opening, and this should be put through the machine a second time. For grass, hand-feeding is better than a self-feeder. The heads should be held to the drum for a short time, and feeding should be rather slow. Four hundredweight of seed per hour from a 4½ ft. drum is a reasonable output.

CLOVER SEED Although clover is generally treated in hulling machines, attachments can be bought to convert corn threshers for the purpose. One type of attachment consists of a special cylinder and wire cage mounted on top of the thresher. The cylinder is driven from one of the shafts of the thresher. A small aspirator fan fitted to the sill picks up the incompletely threshed clover heads from the lower shoe cross-sieve and delivers them to the auxiliary cylinder. A back-plate for the concave of the main threshing drum, a special clover sieve in the cross-spout of the lower shoe, and a special sieve for the second dresser, are also needed.

The other type of attachment can be used only with machines for which it is specifically manufactured. It does not provide a separate hulling cylinder, but it converts the ordinary drum to a combined threshing and hulling drum. This attachment consists of a set of special steel beater plates and bolts for the drum, a pair of special concaves, a set of seed riddles, and a wind baffle for the second dresser shoe.

Clover hullers also make a very clean sample of timothy; indeed they provide the only really satisfactory apparatus for dealing with valuable pedigree strains of this grass. Commercial strains of timothy can, however, be threshed well enough with an ordinary thresher in good condition. A caving riddle with the two sections nearest the drum made with ⅛-in. mesh, and the other sections of 3/32-in., should be fitted and the screens on the first and second dresser should both have 3/32-in. mesh. The blast from both first and second blowers should be low.

Linseed—Under some conditions the threshing of linseed has proved to be awkward, but once the pecularities of the crop, and its differences in behaviour, compared with a corn crop, are understood and allowed for, a good job of threshing results provided the machine is in sound condition and adjusted correctly. One of the important differences between threshing linseed and corn lies in the lower speed of throughput that can safely be reached.

A good setting of the concave clearance from which to start making adjustments is ½-⅝ in. at the top, ¼-⅜ in. at the middle, and ⅛-in. at the bottom.

As in the case of adapting the machine for grass seed, a metal back-plate should be fitted to the concave, or the back of the concave should be packed with straw. This helps to prevent heads passing through without being rubbed.

Usually the drum need rotate no faster than for corn. The sheaves of linseed must be fed very slowly, and it is best to put them in head first and hold them to the drum for a second or so before letting them go.

At the first dressing shoe the wind must be kept low to prevent seed being blown away with the chaff, but at the second dressing shoe a fair amount of wind may be used.

For linseed, as for grass, it is advisable to close the rotary creen so that the best seed falls through at the end where the ail corn would be discharged, and any unthreshed heads pass ut to the chute where head corn is normally delivered.

In dealing with linseed it must be remembered that oil may e liberated by bruising or excessive rubbing of the seed at the oncave or in the awner.

Linseed threshes much more easily in fine weather. Moreover, the crop itself must be perfectly dry, and it is usually not dvisable to try to thresh direct from the stock. From this ast point it follows that threshing linseed with a combine arvester, cutting and threshing at the same time, has to be lone very skilfully if it is to be successful. The crop must be lead ripe, and work must be started later in the morning than s necessary for a cereal crop. However, most makes of combine an, with correct adjustment, deal with ripe linseed on a fine lry day, particularly if they have been fitted with the special inseed threshing attachments which some makers supply for heir machines. Some makes of machine can have rubber ollers fitted to crack the seed capsules before they pass into he drum ; some can have additional bars fitted between the ormal rasp bars and others have metal sheets fitted to the egular concave.

Some of the difficulties noticed for combining linseed apply lso to the combining of grass seeds. Grass and clover seeds ipen less uniformly than wheat and barley. It is usually etter to cut and windrow grasses and clovers and then pick hem up with the combine.

Whatever the crop, and whether the thresher is stationary or combine harvester, the final adjustments depend upon the ondition of the crop, the humidity of the air, and the direction nd strength of the breeze at the time of threshing. These inal adjustments can be made only by trial and error. In naking them, the guiding principle is that the speed of the drum hould be no faster, the blast no higher, and the concave learance no smaller, than is needed to give complete separation.

ulleys

V = velocity of driving pulley.
D = diameter of driving pulley.
v = velocity of driven pulley.
d = diameter of driven pulley.

$$v = \frac{V\,D,}{d} \qquad d = \frac{V\,D.}{v}$$

In a train of pulleys the final velocity is

$$= \frac{V \times D \times D' \times D\text{-, etc.,}}{d \times d' \times d\text{-, etc.}}$$

where D^1, D^2, are the diameters of the driving pulleys, an *d*¹, *d*², those of the driven.

Convexity of pulley face to receive the belt = ⅛-in. pe foot in high speeds = ¼-in. in low speeds.

Shafting and Belting—The horse power that can be safe transmitted by any arrangement of shaft and belting depen on the size and material of the shaft, the size and materia the belt, the speed of rotation of the shaft, and speed of trav of the belt. In all calculations on the transmission of powe it must be remembered that since work is a product of forc and distance, the slower the speed the greater the force tran mitted, and therefore the stronger the equipment used. I the following tables of horse powers transmissible by variou sizes of steel shafting, a speed of 1 r.p.m. has been assumed for a shaft rotating at 500 r.p.m., the figures given for hors power must be multiplied by 500.

TABLE 208.

HORSE POWER TRANSMITTED BY STEEL SHAFTING

Diameter of shaft in.	H.P. per r.p.m.
1	0·015
1¼	0·033
1½	0·062
1¾	0·088
2	0·133
2¼	0·260

Similarly in the following table of horse powers transmitte per inch of width of various kinds of belting a belt velocit of 1 foot per second has been assumed. A similar belt of th same width running five times as fast would transmit five time the horsepower.

HORSE POWER TRANSMITTED PER INCH OF WIDTH OF BELTIN

Kind of belt	H.P.
Single leather	0·090
4-ply cotton	0·090
Light double leather	0·126
6-ply cotton	0·126
Heavy double leather	0·162
8-ply cotton	0·162
½-in. link leather	0·102
¾-in. link leather	0·150
1 in. link leather	0·204

When the size of pulley on the shafting has been decided up the size of pulley needed on the machine, so that its spi shall rotate at the desired speed, can be calculated from th formula :

$$\text{Diameter of pulley on machine} = \frac{\text{Diameter of pulley on shaft} \times \text{speed of shaft}}{\text{Speed of machine}}$$

Example—Suppose none of the machines to be driven demands re than 6 h.p. or if more than one machine will be driven the same time the combined demand will not exceed 6 h.p. ppose, too, the shafting used has a diameter of 1¼ in. Then, m the above tables the shafting must be driven at $\frac{6}{0{\cdot}033}$ .m., say, 190 r.p.m. or more. If a pulley of 12 in. diameter the shaft is used the belt speed will be 190 × π × 12 in. r minute = about 7,166 in. per minute, or $\frac{7166}{12 \times 60}$ =

about 10 ft. per second.

Assume a light leather belt of double thickness is used. e belt must be wide enough to transmit 6 h.p. at a belt speed 10 ft. per second and from the table it is seen each inch width 6-ply cotton belting transmits 0·126 h.p. at a belt speed of ft. per second. At 10 ft. per second it is possible to transmit n times as much horse power, that is, 1·26 h.p. per inch of dth. Therefore, to transmit 6 h.p. a belt $\frac{1 \times 6}{1{\cdot}26}$ = 4¾ in. de is required. If, in the example considered the machine required to rotate at 360 r.p.m., then a pulley having a diameter $\frac{12 \times 190}{360}$ = 6⅓ in. must be fixed

COMPOSITION
AND NUTRITIVE VALUE
OF
THE MORE COMMONLY USED
FEEDINGSTUFFS

The data in this table are derived from Bulletin No. 48 of e Ministry of Agriculture and Fisheries (1952) by permission H.M. Stationery Office. Also, by kind permission, from the llowing sources: Bulletin 156b of the Leeds University Depart- ent of Agriculture, " Feeding of Livestock " by Professor S. J. atson (Nelson and Sons, Ltd., 1949) and from unpublished alyses made at Seale-Hayne Agricultural College.

With the exceptions of " dry matter " and " ash " in columns and 12 respectively the average percentage (crude) composition the feedingstuffs as found by chemical analysis have been nitted. The data in columns 3 to 7 inclusive, therefore, refer the digestible composition and consequently indicate much ore reliably the feeding value of the foods.

FOOD	Dry Matter per cent.	Digestible Nutrients per cent.					"V" Number	Protein Equivalent (P.E.)	Starch Equivalent (S.E.)	Ratio of Starch Equivalent to Protein Equivalent $\frac{SE}{PE}$	Mineral Composition				
												Ash includes			
		Digestible Crude Protein	Digestible True Protein	Digestible Oil (Dig. Ether Extract)	Digestible Carbohydrate (Dig Nitrogen-free Extractives)	Digestible Fibre					Total Ash per cent.	Lime (CaO) per cent.	Phosphoric Acid (P_2O_5) per cent.	Potash (K_2O) per cent.	Chlorine (Cl) per cent.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1. Concentrated Foods															
(A) Carbohydrate Rich															
Barley ..	85	7·6	7·0	1·2	60·9	2·5	98	7·3	71·4	9·8	2·6	0·07	0·84	0·57	0·12
Maize ..	87	7·9	7·4	2·7	63·7	0·8	100	7·7	77·6	10	1·3	0·02	0·82	0·40	0·07
Oats	86·5	8·0	7·2	4·0	44·8	2·6	95	7·6	59·5	7·8	3·1	0·14	0·81	0·55	0·07
Rye	86·5	9·6	8·7	1·1	63·9	1·0	95	9·2	71·6	7·8	2·0	0·07	0·95	0·60	0·02
Wheat	86·5	10·2	9·0	1·2	63·5	0·9	95	9·6	71·6	7·5	1·7	0·05	0·86	0·60	0·08
(B) Protein Rich															
(i) Animal Products															
Blood meal ..	86	72·7	63·6	0·8	—	—	100	68·2	62·9	0·92	2·7	0·05	0·22	0·31	0·85
Feeding meat meal, high fat ..	90·5	56·4	42·4	9·8	0·5	—	100	49·4	72·3	1·46	19·0				
Feeding meat meal, low fat ..	93·0	58·6	43·4	2·4	3·9	—	100	51·0	59·6	1·16	19·4	8·42	7·35	0·72	1·23
Fish meal, white	87·0	55·0	51·0	3·3	1·2	—	100	53·0	58·9	1·11	21·0	10·00	9·00	1·20	1·00
Meat and bone meal	90	39·2	29·2	14·3	—	—	100	34·2	67·8	1·98	24·0	10·50	9·30	0·80	1·40
Meat meal, pure	89	67·2	63·6	12·5	—	—	100	65·4	91	1·39	3·8	0·40	0·70	0·10	0·27

Concentrated foods —contd.															
(ii) Dairy By-products															
*Dried Buttermilk	90	35·3	—	7·0	40·0	—	—	—	—	—	7·7				
*Dried skimmed milk	89·7	32·8	—	1·1	47·9	—	—	—	—	—	7·8				
*Dried whey ..	92·9	12·6	—	1·4	70·5	—	—	—	—	—	7·7				
(iii) Vegetable Origin															
Beans (bean meal)	85·7	20·1	19·3	1·2	44·1	4·1	96	19·7	65·8	3·34	3·2	0·18	0·88	1·28	0·03
Cottonseed cake or meal (decort.)	90·2	38·4	33·9	7·5	17·2	2·2	92	34·7	68·4	1·97	6·8	0·35	2·80	1·80	0·03
Cottonseed cake (undecort.)	87·9	17·8	16·8	4·6	17·7	4·8	84	17·3	41·6	2·40	5·8	0·30	2·80	1·60	0·05
Dried Brewers' Grains	89·7	13·0	12·1	5·6	27·6	7·3	84	12·6	48·3	3·80	3·9	0·40	1·60	0·20	0·06
Dried Distillers' Grains	92·0	19·6	18·7	10·2	25·3	4·8	84	19·2	57·2	2·96	1·8	0·40	0·68	0·20	0·06
Dried Yeast	93·7	38·6	29·4	0·4	34·1	—	100	32·8	68·3	2·10	9·6	0·30	8·80	2·00	0·03
Gound nut cake (decort.)	89·7	42·0	40·6	6·8	19·7	0·8	98	41·3	73·0	1·77	5·8	0·20	1·30	1·50	0·03
Ground nut cake (undecort.)	89·7	27·7	26·8	8·2	18·4	2·6	86	27·3	56·8	2·08	5·7	0·20	1·00	1·10	
Linseed cake	88·8	25·3	23·9	8·7	25·5	4·5	97	24·6	74·0	3·00	5·2	0·51	1·70	1·30	0·09
Linseed or linseed meal ..	92·9	19·4	18·1	34·7	18·3	1·8	99	18·8	119·2	6·34	3·8	0·30	1·40	1·10	0·09
Malt culms ..	90·0	19·9	12·0	1·5	30·9	12·7	75	16·0	43·4	2·70	7·2	0·20	1·80	2·00	0·35
Maize gluten feed	89·6	20·0	18·4	2·7	49·3	2·5	100	19·2	75·6	3·94	2·5	0·10	0·70	0·20	0·04
Palm kernel cake or meal	89·0	17·8	16·4	5·3	39·4	5·1	100	17·0	73·2	4·30	3·8	0·30	1·10	0·50	0·16
Palm kernel meal (extracted)	90·0	17·1	16·0	1·9	43·5	8·0	100	16·6	71·3	4·29	4·0	0·30	1·20	0·50	
Peas or Pea meal	86·0	19·4	16·9	1·0	49·9	2·5	98	18·2	69·0	3·79	2·8	0·10	0·90	1·00	0·04
Soya bean cake	85·8	38·8	35·0	5·1	20·4	3·7	97	36·9	68·9	1·87	5·4	0·30	2·00	1·80	0·03
Soya bean meal (extracted)	88·7	40·3	36·3	1·4	24·7	3·6	97	38·3	64·0	1·67	5·5	0·30	2·10	1·90	0·03
(iv) Wheat Feeds															
Fine Grade (75% extraction)	87	12·2	—	3·1	41·2	2·0	80	—	49·0	4·1†	4·0				

* Average composition per cent. as shown by chemical analysis.   † Nutritive ratio.

		Digestible Nutrients per cent.										Mineral Composition			
												Ash includes			
	Dry Matter per cent.	Digestible Crude Protein	Digestible True Protein	Digestible Oil (Dig. Ether Extract)	Digestible Carbohydrate (Dig. Nitrogen-free Extractives)	Digestible Fibre	" V " Number	Protein Equivalent (P.E.)	Starch Equivalent (S.E.)	Ratio of Starch Equivalent to Protein Equivalent $\frac{SE}{PE}$	Total Ash per cent.	Lime (CaO) per cent.	Phosphoric Acid (P_2O_5) per cent.	Potash (K_2O) per cent.	Chlorine (Cl) per cent.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Concentrated foods —contd.															
Fine Bran (85% extraction)	87	10·8	—	2·6	39·6	1·9	77	—	44·0	4·4*	4·4				
Coarse Bran (85% extraction) . .	87	11·0	—	0·9	37·5	2·8	77	—	40·4	3·9*	5·1				
Fine Millers' Offals (85% extraction)	87	9·9	—	2·4	38·7	3·3	77	—	43·4	4·8*	4·9				
Coarse Millers' Offals (85% ext.)	87	7·6	—	0·1	34·8	4·4	75	—	34·9	5·2*	6·0				
II. Coarse Fodders (A) Hays															
Lucerne, before flowering	85	12·2	8·2	1·1	21·4	11·4	72	10·2	32·2	3	7·4				
Lucerne, full flower	85	9·9	6·3	1·2	18·4	13·4	65	8·1	27·1	3	8·1	2·77	0·51	1·54	0·34
Meadow, all leaf . .	85	9·3	6·6	1·5	30·5	12·8	92	8·0	49·3	6	7·8	2·00	0·60	2·00	

* Nutritive Ratio.

—contd.															
Meadow, early flower	85	5·4	4·5	0·8	25·3	18·2	86	5·0	40·5	8	6·8				
Meadow, flowering	85	3·4	2·8	0·7	24·5	17·9	76	3·1	35·6	11	6·4	1·00	0·43	1·60	0·37
Meadow, full flower	85	2·4	1·6	0·6	25·4	16·8	72	2·0	32·5	16	5·3				
Oat and vetch ..	85	6·6	4·2	1·7	23·6	12·4	78	5·4	34·7	7	8·7				
Sainfoin, before flowering ..	85	11·0	7·9	2·1	25·4	10·8	81	9·5	39·6	4	6·8				
Seeds, high clover	85	7·9	6·1	0·7	31·1	12·2	88	7·0	45·0	6	7·2	2·0	0·6	1·8	
Seeds, medium clover	85	5·0	3·9	0·6	30·4	15·1	84	4·5	42·8	10	6·3	2·00	0·60	1·80	0·30
Seeds, low clover ..	85	3·9	3·1	0·6	32·0	15·7	85	3·5	44·3	13	5·8				
(B) Straws															
Barley	86·0	0·8	0·6	0·6	22·5	18·3	54	0·7	23	32·9	4·6	0·50	0·20	1·20	0·35
Bean (including pods) ..	86·0	2·2	1·3	0·5	22·0	18·7	43	1·8	19	10·5	4·6	1·20	0·30	1·90	
Oat (Spring) ..	86·0	1·0	0·8	0·6	19·4	18·3	50	0·9	20	22·2	4·9	0·36	0·18	1·50	0·30
Pea	86·4	4·3	3·4	0·7	18·5	13·7	45	3·9	17	4·36	6·6	1·60	0·40	1·00	
Rye	86·0	0·6	0·4	0·8	17·0	17·3	41	0·5	15	30·0	4·1	0·35	0·25	0·80	
Wheat (Winter) ..	86·0	0·1	—	0·4	15·0	18·3	38	—	13	342*	5·3	0·29	0·13	0·80	0·20
III. Succulent Foods															
(A) Green Foods															
Cabbage, drumhead	11·0	1·1	0·7	0·2	4·6	1·4	94	0·9	6·6	7·33	1·2	0·20	0·10	0·40	0·02
Cabbage, open-leaved ..	15·3	1·8	1·2	0·4	6·5	1·7	94	1·5	9·5	6·33	1·6	0·25	0·15	0·50	
Kale, marrow stem (unthinned)	14·0	1·7	1·1	0·3	6·1	1·6	93	1·4	9·1	6·5	1·9	0·43	0·12	0·55	0·21
Kale, thousand-headed	15·8	1·7	1·2	0·17	7·5	1·8	92	1·5	10·3	6·9	1·7	0·39	0·13	0·52	0·16
Rape	14·1	2·0	1·3	0·5	3·9	1·9	87	1·7	6·9	4·0	1·6	0·20	0·15	0·30	
(B) Roots and Tubers															
Carrots	13·0	0·8	0·4	0·1	8·9	0·7	87	0·6	8·8	14·7	0·9	0·09	0·11	0·30	
Kohl Rabi ..	12·7	0·7	0·3	—	7·4	0·6	90	0·5	8·3	16·6	1·0	0·13	0·13	0·35	0·06
Mangolds (Yellow fleshed globe) ..	13·2	0·7	0·1	—	9·4	0·3	70	0·4	6·8	17·0	0·9	0·02	0·09	0·45	0·16
Potatoes	23·8	1·1	0·6	—	17·7	—	100	0·9	18·5	20·6	1·0	0·03	0·18	0·60	0·04
Sugar beet ..	23·4	0·8	0·3	—	19·3	0·4	75	0·6	15·0	25·0	0·7	0·05	0·10	0·35	0·06
Swedes	11·5	1·1	0·3	—	7·5	0·8	85	0·7	7·3	10·4	0·7	0·08	0·08	0·30	0·04
Turnips	8·5	0·6	0·2	—	5·2	0·3	77	0·4	4·4	11·0	0·7	0·07	0·09	0·30	0·04

* Nutritive ratio.

		Digestible Nutrients per cent.									Mineral Composition				
												Ash includes			
	Dry Matter per cent.	Digestible Crude Protein	Digestible True Protein	Digestible Oil (Dig. Ether Extract)	Digestible Carbohydrate (Dig. Nitrogen-free Extractives)	Digestible Fibre	" V " Number	Protein Equivalent (P.E.)	Starch Equivalent (S.E.)	Ratio of Starch Equivalent to Protein Equivalent $\frac{SE}{PE}$	Total Ash per cent.	Lime (CaO) per cent.	Phosphoric Acid (P_2O_5) per cent.	Potash (K_2O) per cent.	Chlorine (Cl) per cent.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Succulent foods—contd.															
(C) Silage															
Clover	20	2·7	1·6	0·6	4·7	3·2	81	2·1	8·9	3	2·3				
Grass, leafy . .	20	2·8	1·2	0·5	7·2	4·0	89	2·0	12·4	4	1·8	0·25	0·20		
Grass, early flowering . .	25	2·1	0·6	0·6	9·0	5·6	85	1·4	14·5	7	2·3				
Grass, full flower . .	25	1·2	0·5	0·5	6·9	5·8	79	0·9	11·4	10	2·7				
Kale, marrow stem	16	1·5	1·0	0·4	6·1	2·8	90	1·3	9·8	7	2·5				
Lucerne	17	2·5	1·5	0·7	3·3	2·1	81	2·0	7·0	3	2·1				
Maize	20	1·4	0·6	1·0	7·5	3·2	90	1·0	12·1	9	1·2				
Pea haulm and pods	25	2·1	0·2	1·4	6·3	3·6	83	1·2	11·5	5	4·3	0·54	0·16		0·11
Potato, steamed . .	25	1·5	0·7	0·1	17·2	0·4	100	1·1	18·6	12	2·3				
Potato haulms . .	25	1·2	0·3	1·2	5·0	1·7	86	0·7	8·3	7	5·6				
Sugar beet tops . .	25	1·6	0·2	0·3	7·8	2·7	91	0·9	10·8	7	8·0				
Vetch-oat	25	1·9	0·9	0·5	6·7	4·8	78	1·4	10·8	6	2·9				
(D) Miscellaneous															
Brewers' Grains, wet	32·4	5·5	5·2	2·4	9·1	2·4	86	5·4	18·4	3·40	1·4	0·10	0·40	0·05	0·02
Distillers' Grains, wet	26·2	6·2	5·8	2·6	6·4	1·7	86	6·0	16·2	2·7	0·8	0·10	0·40	0·05	

Succulent foods —contd															
Lucerne (in bud)	22·0	3·6	2·4	0·1	6·8	3·1	84	3·0	11·3	3·77	1·8	0·77	0·14	0·56	0·05
Red clover (beginning to flower)	19·0	2·5	1·7	0·5	6·3	3·0	86	2·1	10·2	4·81	1·6	0·40	0·15	0·50	0·05
Sugar beet pulp, wet	11·6	0·5	0·3	0·1	5·4	1·2	90	0·4	6·5	16·3	0·9				
Vetches (early flowering stage)	17·5	2·2	1·4	0·3	4·9	2·3	83	1·8	7·5	4·17	1·5	0·50	0·15	0·50	
White clover (beginning to flower)	18·5	2·8	1·9	0·5	4·7	2·6	88	2·4	8·8	3·67	2·1				
IV. Grassland															
(A) Pasture Grass															
Very leafy	18	3·3	2·3	0·3	6·1	3·0	88	2·8	10·8	4	2·3				
Leafy	19	2·5	1·8	0·3	6·7	3·6	87	2·2	11·3	5	2·2	0·35	0·20	0·75	0·24
Little stem, early flowering stage	21	2·1	1·6	0·4	7·5	4·2	86	1·9	12·2	6	2·1				
Stemmy, flowering stage	23	1·6	1·3	0·3	8·4	4·6	85	1·5	12·7	9	2·2				
Seed set, full flower	25	1·3	1·0	0·3	9·3	4·8	81	1·2	12·8	10	1·8				
(B) Artificially Dried Crop															
Grass, very leafy	90	14·1	13·0	1·7	30·5	13·3	90	13·6	54·1	4	10·0	1·35	1·00		
,, leafy	90	10·0	8·6	1·5	31·0	15·9	88	9·3	51·7	6	10·8	1·20	0·90		
,, little stem, early flowering	90	7·3	6·4	1·1	31·4	18·8	87	6·8	51·2	7	9·0	0·88	0·78		
,, stemmy, flowering	90	5·8	5·1	1·2	30·9	18·6	87	5·5	49·5	9	10·3				
Lucerne or clover—															
bud stage	91	15·9	11·2	1·3	25·4	9·5	94	13·6	50·1	4	11·4				
early flowering	91	11·6	9·3	0·7	27·8	11·2	88	10·5	44·1	4	10·2				
Clover meal	90	5·7	4·2	0·6	30·5	19·0	76	5·0	42·0	8	7·6				

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